

OBJECT-ORIENTED PROGRAMMING APPARATUS, OBJECT-ORIENTED  
PROGRAMMING SUPPORTING APPARATUS, COMPONENT BUILDER  
APPARATUS, OBJECT-ORIENTED PROGRAM STORAGE MEDIUM, PROGRAM  
STORAGE MEDIUM FOR USE IN OBJECT-ORIENTED PROGRAMMING,  
COMPONENT STORAGE MEDIUM, AND OBJECT-BETWEEN-NETWORK DISPLAY  
METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an object-oriented programming apparatus for performing an object-oriented programming, an object-oriented programming supporting apparatus for supporting an object-oriented programming, a component builder apparatus for building components forming a part of an object, an object-oriented program storage medium for storing therein object-oriented programs, a program storage medium for use in an object-oriented programming, the program storage medium being adapted for storing therein a program to support an object-oriented programming, a component storage medium for storing therein components, and an object-between-network display method of visually displaying in the form of a network of objects, a data integration due to a data sharing, an integration of control

A  
A  
flows among objects<sup>9</sup> and the like, on a plurality of objects produced by ~~the~~ object-oriented programming.

#### Description of the Related Art

Hitherto, when a program, which is incorporated into a computer so as to be operated, is described, a programming is performed in such a manner that a function name (command) and a variable are described in turn. In case of such a programming scheme, since there is a need to describe the programming with the commands in its entirety, it is necessary for a programmer to investigate the commands one by one through a manual, or to remember a lot of commands. However, those commands are different for each program language. Accordingly, even if a programmer remembers a lot of commands of a certain program language, when the programmer describes a program with another program language, there occurs such an inconvenience that the programmer has to do over again learning the commands of the program language. Further, formats of programs are also different for each program language. These matters make a description of the program difficult, and give such an impression that a development of programs is a special field which is deemed that it is difficult for a nonprofessional to enter thereinto. Recently, programs are increasingly large-scaled and complicated, and thus there is emphasized more and more a

necessity that a development of programs is made easier, and also a necessity for contributing to a reuse of the once developed programs.

In such a technical background, recently, ~~an~~ object-oriented programming has been widely adopted. An object is a named entity that combines a data structure with its associated operations. That is, the object comprises "data" and "its associated operations". The term "object-oriented" implies a concept that the "data" and ~~the~~ "its associated operations", that is, the object, is treated in the form of units. Also in such an object-oriented programming, there is a need to essentially build each individual software (object). After the individual objects are once built, however, a programming is completed in such a manner that a coupling relation of object-to-object is described such that a certain object calls another object. It is expected that <sup>this concept of</sup> ~~the~~ object-oriented programming ~~taking in~~ ~~such a concept~~ serves to significantly improve an operability of ~~software~~ <sup>software, the creation</sup> large-scaled and complicated ~~a method of making~~ <sup>up</sup> ~~such a~~ software, and the maintenance thereof.

In ~~the~~ object-oriented programming, an operation in which a certain object calls another object uses concepts of messages and methods such that the calling object issues a message to the called party of <sup>the</sup> ~~an~~ object, while the called party

<sup>the</sup>  
of<sub>A</sub> object receives the issued message and executes its associated methods (operations). Hitherto, data necessary for a process<sub>A</sub> <sup>was</sup> ~~of the methods~~ is provided in the form of arguments of the messages.

One of the objects of ~~the~~ object-oriented programming resides in the point that ~~a~~ software (object) once made up can be reused even if the system is altered. In order to implement this, there is a need to make up a relatively small and simple object.

In general, however, it is said that <sup>an</sup> ~~the~~ object-oriented program is low in its execution rate because it takes a lot of time to recognize a corresponding relation between the received message and its associated method, and also it takes a lot of time to transfer data from an object, which issues the message, to an object which executes the method.

In order to improve the program execution rate, hitherto, there <sup>was</sup> ~~is~~ adopted a technique in which operations in one object are increased to reduce opportunities of issuing messages directed to another object. In this case, however, the operations in one object <sup>become</sup> ~~is~~ complicated, and the object is scaled up. <sup>This technique is</sup> ~~They are~~ <sup>desire for</sup> contrary to the ~~above-mentioned~~ <sup>reusable objects</sup> ~~reuse~~, and thus, <sup>it</sup> is one of the causes of prohibiting the possibility of promoting reuse of the software in the



object-oriented programming.

When the object-oriented programs are promoted, the serious problem is involved in handling of a large <sup>amount</sup> number of <sup>software</sup> ~~softwares~~ accumulated up to now, which <sup>is</sup> ~~are~~ not based on ~~a~~ <sup>an object-oriented concept.</sup> ~~concept referred to an object-oriented~~. The object-oriented programming technology according to the earlier development has been associated with such a problem that the possibility of promoting reuse of the existing <sup>software</sup> ~~soft-ware~~ is extremely low.

#### SUMMARY OF THE INVENTION

In view of the above-mentioned problem, it is therefore an object of the present invention to provide an object-oriented programming apparatus having a function of coupling a plurality of objects with one another so that information efficiently flows among the plurality of objects, an object-oriented program storage medium for storing therein a plurality of objects and object-coupling programs for coupling the plurality of objects with one another so that information efficiently flows among the plurality of objects, an object-oriented programming supporting apparatus which contributes to facilitation of an object-oriented programming for defining a coupling relation between objects, a program storage medium for use in an object-oriented programming, the program storage medium being adapted for storing therein a

program to support an object-oriented programming, a component builder apparatus having a function of building a component which serves as an object in combination with an existing software so that the existing software can be dealt with as the object, a component storage medium for storing therein components as mentioned above, and an object-between-network display method of visually displaying in the form of a network of objects a data integration due to a data sharing, an integration of control flows among objects and the like, on a plurality of objects produced by the object-oriented programming, the object-between-network display method being suitable for performing an object-oriented programming for defining a coupling relation between objects.

To attain the above-mentioned object, according to the present invention, there is provided a first object-oriented programming apparatus for interconnecting a plurality of objects each having data and operations, said object-oriented programming apparatus comprising:

instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to



a pointer to another object in which the method specified by the method ID is executed.

To attain the above-mentioned object, according to the present invention, there is provided a second object-oriented programming apparatus for interconnecting a plurality of objects each having data and operations, said object-oriented programming apparatus comprising:

instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the method of the second object; and

an input instruction tag table generating means for generating an input instruction tag table indicating an association of messages of another object with methods of self object, for each other object, on the output instruction bus portion of self object.

In the second object-oriented programming apparatus, it is preferable that said instruction coupling means

generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

said input instruction tag table generating means generates the input instruction tag table and adds the input instruction tag table to the method elements including the pointer to another object associated with the input instruction tag table.

As one of ways that the input instruction tag table is added to the method element, it is acceptable that a pointer to the input instruction tag table is directly written to the method element.

To attain the above-mentioned object, according to the present invention, there is provided a third object-oriented programming apparatus for interconnecting a plurality of objects each having data and operations, said object-oriented programming apparatus comprising:

instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to

messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the method of the second object; and

an output instruction tag table generating means for generating an output instruction tag table indicating an association of methods of another object with messages of self object, for each other object, on the output instruction bus portion of self object.

In the third object-oriented programming apparatus, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

said output instruction tag table generating means generates the output instruction tag table and adds the output instruction tag table to the method elements including the pointer to another object associated with the output instruction tag table.

As one of ways that the output instruction tag table is added to the method element, it is acceptable that a

pointer to the output instruction tag table is directly written to the method element.

To attain the above-mentioned object, according to the present invention, there is provided a fourth object-oriented programming apparatus for interconnecting a plurality of objects each having data and operations, said object-oriented programming apparatus comprising:

instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the method of the second object; and

an input data tag table generating means for generating an input data tag table indicating an association of a data element list ID for identifying a data element list in which pointers to data storage areas for storing data are arranged with a pointer element list ID for identifying a pointer element list in which pointers to data storage areas for storing pointer to data are arranged, for each

other object, on the output instruction bus portion of self object.

In the fourth object-oriented programming apparatus, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

said input data tag table generating means generates the input data tag table and adds the input data tag table to the method elements including the pointer to another object associated with the input data tag table.

As one of ways that the input data tag table is added to the method element, it is acceptable that a pointer to the input data tag table is directly written to the method element.

To attain the above-mentioned object, according to the present invention, there is provided a fifth object-oriented programming apparatus for interconnecting a plurality of objects each having data and operations, said object-oriented programming apparatus comprising:

instruction coupling means for permitting a transfer of messages between a first object having an output



instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the method of the second object; and

an output data tag table generating means for generating an output data tag table indicating an association of a pointer element list ID for identifying a pointer element list in which pointers to pointer storage areas for storing pointers to data are arranged with a data element list ID for identifying a data element list in which pointers to data storage areas for storing data are arranged, for each other object, on the output instruction bus portion of self object.

In the fifth object-oriented programming apparatus, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

said output data tag table generating means generates the output data tag table and adds the output data tag table to the method elements including the pointer to another object associated with the output data tag table.

As one of ways that the output data tag table is added to the method element, it is acceptable that a pointer to the output data tag table is directly written to the method element.

To attain the above-mentioned object, according to the present invention, there is provided a first object-oriented program storage medium for storing

a plurality of objects each having data and operations, said object-oriented program storage medium storing

an object coupling program comprising:

instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the

method of the second object;

data element list generating means for generating a data element list, in which pointers to data storage areas for storing data are arranged, of an object;

pointer element list generating means for generating a pointer element list, in which pointers to pointer storage areas for storing pointers to data are arranged, of an object; and

data coupling means for permitting a transfer of data between a third object having the data element list and a fourth object having the pointer element list, by means of writing the pointers arranged in the data element list of the third object into the pointer storage areas indicated by the pointers arranged in the pointer element list of the fourth object.

In the first object-oriented program storage medium, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

the first object having the output instruction bus portion refers to, when issuing a message, a method element

arranged in the method element list associated with the message, and calls the second object in which a pointer is stored in the method element, giving the method ID stored in the method element as an argument.

In this case, the second object receives messages directed from the first object to the second object, and executes the method identified by the method ID which is an argument of the received message.

To attain the above-mentioned object, according to the present invention, there is provided a second object-oriented program storage medium for storing

a plurality of objects each having data and operations, said object-oriented program storage medium storing

an object coupling program comprising:

instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the

method of the second object; and

an input instruction tag table generating means for generating an input instruction tag table indicating an association of messages of another object with methods of self object, for each other object, on the output instruction bus portion of self object.

In the second object-oriented program storage medium, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

said input instruction tag table generating means generates the input instruction tag table and adds the input instruction tag table to the method elements including the pointer to another object associated with the input instruction tag table.

As one of ways that the input instruction tag table is added to the method element, it is acceptable that a pointer to the input instruction tag table is directly written to the method element.

It is acceptable that the first object having the method element to which the input instruction tag table is

added calls, when calling the second object identified by the method element, the second object giving as arguments the method ID and the input instruction tag table which are stored in the method element.

As one of ways that the second object is called giving as arguments the input instruction tag table, it is acceptable that the second object is directly called giving as arguments a pointer to the input instruction tag table.

In this case, the second object receives messages directed from the first object to the second object, and executes the method identified by the method ID which is an argument of the received message.

It is acceptable that the second object receives messages directed from the first object to the second object, and refers to the input instruction tag table, which is an argument of the received message, to execute the method of the first object associated with the message of the second object.

It is preferable that the second object receives messages directed from the first object to the second object, and refers to the input instruction tag table, which is an argument of the received message, to add the method element related to the method of the first object associated with the message of the second object to the method element list of

the second object associated with the message of the second object.

It is also preferable that the second object has means for producing a third object, receives messages directed from the first object to the second object, and refers to the input instruction tag table, which is an argument of the received message, to add the method element related to the method of the first object associated with messages of the third object to the method element list of the third object associated with the message of the third object.

In this case, a timing of producing the third object by the second object is not restricted in the present invention, and it is acceptable that the third object is produced when the message is issued, alternatively, the third object is produced beforehand.

To attain the above-mentioned object, according to the present invention, there is provided a third object-oriented program storage medium for storing

a plurality of objects each having data and operations, said object-oriented program storage medium storing

an object coupling program comprising:

an instruction coupling means for permitting a

transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the method of the second object; and

an output instruction tag table generating means for generating an output instruction tag table indicating an association of methods of another object with messages of self object, for each other object, on the output instruction bus portion of self object.

In the third object-oriented program storage medium, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

said output instruction tag table generating means generates the output instruction tag table and adds the output instruction tag table to the method elements including



the pointer to another object associated with the output instruction tag table.

As one of ways that the output instruction tag table is added to the method element, it is acceptable that a pointer to the output instruction tag table is directly written to the method element.

It is acceptable that the first object having the method element to which the output instruction tag table is added calls, when calling the second object identified by the method element, the second object giving as arguments the method ID and the output instruction tag table which are stored in the method element.

As one of ways that the second object is called giving as arguments the output instruction tag table, it is acceptable that the second object is directly called giving as arguments a pointer to the output instruction tag table.

In this case, the second object receives messages directed from the first object to the second object, and executes the method identified by the method ID which is an argument of the received message.

It is acceptable that the second object receives messages directed from the first object to the second object, and refers to the output instruction tag table, which is an argument of the received message, to add the method element

related to the method of the second object associated with the message of the first object to the method element list of the first object associated with the message of the first object.

It is preferable that the second object has means for producing a third object, receives messages directed from the first object to the second object, and refers to the output instruction tag table, which is an argument of the received message, to add the method element related to the method of the third object associated with messages of the first object to the method element list of the first object associated with the message of the first object.

In this case, similar to the second object-oriented program storage medium, a timing of producing the third object by the second object is not restricted in the present invention, and it is acceptable that the third object is produced when the message is issued, alternatively, the third object is produced beforehand.

To attain the above-mentioned object, according to the present invention, there is provided a fourth object-oriented program storage medium for storing

a plurality of objects each having data and operations, said object-oriented program storage medium storing

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an object coupling program comprising:

an instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the method of the second object; and

an input data tag table generating means for generating an input data tag table indicating an association of a data element list ID for identifying a data element list in which pointers to data storage areas for storing data are arranged with a pointer element list ID for identifying a pointer element list in which pointers to data storage areas for storing pointer to data are arranged, for each other object, on the output instruction bus portion of self object.

In the fourth object-oriented program storage medium, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of

another object associated with a message of self object, and  
a pointer to another object in which the method specified by  
the method ID is executed, and

said input data tag table generating means generates the input data tag table and adds the input data tag table to the method elements including the pointer to another object associated with the input data tag table.

As one of ways that the input data tag table is added to the method element, it is acceptable that a pointer to the input data tag table is directly written to the method element.

It is acceptable that the first object having the method element to which the input data tag table is added calls, when calling the second object identified by the method element, the second object giving as arguments the method ID and the input data tag table which are stored in the method element.

As one of ways that the second object is called giving as arguments the input data tag table, it is acceptable that the second object is directly called giving as arguments a pointer to the input data tag table.

In this case, the second object receives messages directed from the first object to the second object, and executes the method identified by the method ID which is an

argument of the received message.

It is acceptable that the second object receives messages directed from the first object to the second object, refers to the input data tag table, which is an argument of the received message, to obtain the pointer element list ID of the first object, produces the pointer element list identified by the pointer element list ID, of the first object and in addition the data element list identified by the data element list ID associated with the pointer element list ID, of the second, and writes the pointers arranged in the data element list of the second object into the pointer storage areas indicated by the pointers arranged in the pointer element list of the first object.

It is preferable that the second object has means for producing a third object, receives messages directed from the first object to the second object, refers to the input data tag table, which is an argument of the received message, to obtain the pointer element list ID of the first object, produces the pointer element list identified by the pointer element list ID, of the first object and in addition the data element list identified by the data element list ID associated with the pointer element list ID, of the third, and writes the pointers arranged in the data element list of the third object into the pointer storage areas indicated by

the pointers arranged in the pointer element list of the first object.

In this case, a timing of producing the third object by the second object is not restricted in the present invention, and it is acceptable that the third object is produced when the message is issued, alternatively, the third object is produced beforehand.

To attain the above-mentioned object, according to the present invention, there is provided a fifth object-oriented program storage medium for storing

a plurality of objects each having data and operations, said object-oriented program storage medium storing

an object coupling program comprising:

an instruction coupling means for permitting a transfer of messages between a first object having an output instruction bus portion for performing a processing for an issue of messages directed to another object and a second object having an input instruction bus portion responsive to messages issued by another object and directed to self object for activating a method of self object associated with the received message, by means of providing such a correspondence that the message of the first object is associated with the method of the second object; and

an output data tag table generating means for generating an output data tag table indicating an association of a pointer element list ID for identifying a pointer element list in which pointers to pointer storage areas for storing pointers to data are arranged with a data element list ID for identifying a data element list in which pointers to data storage areas for storing data are arranged, for each other object, on the output instruction bus portion of self object.

In the fifth object-oriented program storage medium, it is preferable that said instruction coupling means generates a method element list in which arranged are method elements including a method ID for specifying a method of another object associated with a message of self object, and a pointer to another object in which the method specified by the method ID is executed, and

said output data tag table generating means generates the output data tag table and adds the output data tag table to the method elements including the pointer to another object associated with the output data tag table.

As one of ways that the output data tag table is added to the method element, it is acceptable that a pointer to the output data tag table is directly written to the method element.

It is acceptable that the first object having the method element to which the output data tag table is added calls, when calling the second object identified by the method element, the second object giving as arguments the method ID and the output data tag table which are stored in the method element.

As one of ways that the second object is called giving as arguments the output data tag table, it is acceptable that the second object is directly called giving as arguments a pointer to the output data tag table.

In this case, the second object receives messages directed from the first object to the second object, and executes the method identified by the method ID which is an argument of the received message.

It is acceptable that the the second object receives messages directed from the first object to the second object, refers to the output data tag table, which is an argument of the received message, to obtain the data element list ID of the first object, produces the data element list identified by the data element list ID, of the first object and in addition the pointer element list identified by the pointer element list ID associated with the data element list ID, of the second, and writes the pointers arranged in the data element list of the first object into the pointer storage



areas indicated by the pointers arranged in the pointer element list of the second object.

It is preferable that the second object has means for producing a third object, receives messages directed from the first object to the second object, refers to the output data tag table, which is an argument of the received message, to obtain the data element list ID of the first object, produces the data element list identified by the data element list ID, of the first object and in addition the pointer element list identified by the pointer element list ID associated with the data element list ID, of the third, and writes the pointers arranged in the data element list of the first object into the pointer storage areas indicated by the pointers arranged in the pointer element list of the third object.

In this case, a timing of producing the third object by the second object is not restricted in the present invention, and it is acceptable that the third object is produced when the message is issued, alternatively, the third object is produced beforehand.

To attain the above-mentioned object, according to the present invention, there is provided an object-between-network display method in which a plurality of objects produced by an object-oriented programming and wirings representative of flow of data and control among the

plurality of objects are displayed on a display screen of an image display apparatus for displaying images based on electronic image information,

wherein displayed on the display screen is a first image in which a display area consisting of one measure obtained through partitioning the display screen into a plurality of measures, or a display area formed through coupling a plurality of adjacent measures together, comprises an object display domain for displaying a single object, and a wiring display domain for displaying wires for coupling a plurality of objects to one another, the object display domain and the wiring display domain are determined in such a manner that the wiring display domain is formed between the object display domain-to-object display domain of the adjacent two display areas, and

wherein on the display screen each of the plurality of objects is arranged on an associated object display domain of the display area, while the wires for coupling the plurality of objects thus arranged are displayed on the wiring display domains ranged across a plurality of display areas.

According to the object-between-network display method of the present invention, it is possible to obtain an arrangement in which objects are arranged in good order,

and also to obtain a display easy for an observation avoiding an overlap of objects with wirings, since an area for displaying an object and an area for displaying a wiring are distinguished from each other.

In the object-between-network display method as mentioned above, it is preferable that a predetermined object of a plurality of objects constituting the first image is constituted of a subnetwork comprising a plurality of objects, which are of lower class in a hierarchical structure than the predetermined object, and wirings for connecting the later plurality of objects together, and

that when a second image, in which a subnetwork of said predetermined object is displayed instead of a display of said predetermined object in the first image, is displayed instead of the first image, the subnetwork on the first image is displayed in a more enlarged display area than that of said predetermined object, and display areas arranged upper and lower sides and right and left sides of the display area of the subnetwork are altered to display areas enlarged vertically and horizontally, respectively, and regarding display areas located at diagonal positions with respect to the display area of the subnetwork, the display areas are displayed with a same size as that of the first image.

An adoption of the above-mentioned display method

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makes it possible to readily confirm a connecting state of a subnetwork with the neighbor networks.

In the object-between-network display method as mentioned above, it is acceptable that a predetermined object of a plurality of objects constituting the first image is constituted of a subnetwork comprising a plurality of objects, which are of lower class in a hierarchical structure than the predetermined object, and wirings for connecting the later plurality of objects together, and

wherein when a second image, in which a subnetwork of said predetermined object is displayed instead of a display of said predetermined object in the first image, is displayed instead of the first image, the subnetwork on the first image is displayed in a more enlarged display area than that of said predetermined object, and display areas except the display areas of the subnetwork are deformed as compared with the associated display areas on the first image in such a manner that display areas located at a periphery of the second image, and position and size of sides contacting with the second image, are substantially the same ones as display areas located at a periphery of the first image, and position and size of sides contacting with the first image, respectively.

An adoption of the above-mentioned display method

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makes it possible to readily confirm a connecting state of a subnetwork with the neighbor networks. In addition, according to the above-mentioned display method, it is possible to confirm throughout a network displayed before a display of the subnetwork (a first image) in the state that the subnetwork is displayed.

In the object-between-network display method as mentioned above, it is preferable that when the first image is displayed, figures and sizes of the object display domains in the display areas are standardized in accordance with figures and sizes of the display areas.

This feature makes it possible to provide a display screen easier to see.

In the object-between-network display method as mentioned above, it is preferable that when the first image is displayed, first, the plurality of objects are displayed, and then it is displayed that the plurality of objects are interconnected with wirings in which a direction of flow of data or control is repeatedly displayed in units of predetermined segments.

An adoption of such a wiring makes it possible, even in the event that an object is out of a display screen, to readily determine as to which side of the wiring input or output exists at. It is acceptable that after the wiring,

such a wire is replaced by the usual wire, for example, a wire in which arrows are given for only one edge or both edges of the wire.

In the object-between-network display method as mentioned above, it is preferable that when the first image is displayed, in wirings consisting of a central wire and edge wires extended along both sides of the central wire, each of the edge wire having a display aspect different from the central wire, there is provided such a display of wiring that of the intersecting wirings, with respect to wirings each representative of a same flow of data or control, the central wire-to-central wire are continued, and with respect to wirings each representative of a mutually different flow of data or control, the central wire of one of the wirings is divided into parts at a position contacting with or adjacent to the edge wires of another wiring.

An adoption of such a wiring makes it possible to readily determine as to whether the intersecting wires are interconnected or simply cross each other.

To attain the above-mentioned object, according to the present invention, there is provided a first object-oriented programming supporting apparatus for coupling a plurality of objects, each having data and operations, with one another in accordance with an

instruction, said object-oriented programming supporting apparatus comprising:

display means for displaying objects each represented by a block representative of a main frame of an object, a data output terminal for transferring data of the object to another object, a data input terminal for receiving data from another object, a message terminal for issuing a message to make a request for processing to another object, and a method terminal for receiving a processing request from another object to execute a method, the object being represented by a hierarchical structure which permits one or a plurality of objects to exist in a single object, and in addition displays a wiring for coupling terminals of a plurality of objects;

object coupling means for constructing a coupling structure among a plurality of objects in accordance with an instruction for coupling terminals of the plurality of objects through a wiring;

hierarchical structure construction means for constructing a hierarchical structure of objects; and

a handler for instructing a wiring for coupling among objects to said object coupling means, and in addition for instructing a position of an object on the hierarchical structure to said hierarchical structure construction means,

wherein said hierarchical structure construction

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means has means for producing a duplicate object of a substantial object designated in accordance with an instruction from said handler, and for disposing the duplicate object at a hierarchy different from a hierarchy at which the substantial object is disposed, and

said object coupling means receives from said handler an instruction as to a wiring between the duplicate object and another object in the wiring of the hierarchical structure in which the duplicate object is disposed, and constructs a coupling structure in which the duplicate object and the associated substantial object are provided in the form of a united object.

The feature such that the duplicate object is built, and a coupling structure, in which the duplicate object and the associated substantial object are provided in the form of a united object, is constructed, makes it possible to arbitrarily dispose one object at desired plural hierarchies to conduct a wiring (an instruction of coupling), thereby making it easy to conduct a wiring among objects located at mutually different hierarchies and also making it possible to provide a display easy to see visually.

To attain the above-mentioned object, according to the present invention, there is provided a second object-oriented programming supporting apparatus for coupling





wherein said object coupling means releases a coupling structure of the object before a replacement with another object in accordance with an instruction from said handler, and causes the object after the replacement to succeed to the coupling structure of the object before the replacement with another object, and

said hierarchical structure construction means disposes the object after the replacement, instead of the object before the replacement, at a hierarchy at which the object before the replacement is disposed.

For a replacement of objects, usually, first, a wiring of an object before a replacement will be removed, and then a new wiring will be conducted for a new object by which the object before a replacement is replaced. On the contrary, according to the present invention, the wiring (a coupling relation) of the object before a replacement is maintained for the new object after a replacement. This feature makes it possible to save trouble for a wiring between the new object after a replacement and other object, thereby making it very easy to conduct a replacement of objects and as a result making the object-oriented programming easy.

To attain the above-mentioned object, according to the present invention, there is provided a third

object-oriented programming supporting apparatus for coupling a plurality of objects, each having data and operations, with one another in accordance with an instruction, said object-oriented programming supporting apparatus comprising:

display means for displaying objects each represented by a block representative of a main frame of an object, a data output terminal for transferring data of the object to another object, a data input terminal for receiving data from another object, a message terminal for issuing a message to make a request for processing to another object, and a method terminal for receiving a processing request from another object to execute a method, the object being represented by a hierarchical structure which permits one or a plurality of objects to exist in a single object, and in addition displays a wiring for coupling terminals of a plurality of objects;

object coupling means for constructing a coupling structure among a plurality of objects in accordance with an instruction for coupling terminals of the plurality of objects through a wiring;

hierarchical structure construction means for constructing a hierarchical structure of objects; and

a handler for instructing a wiring for coupling among objects to said object coupling means, and in addition for

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instructing a position of an object on the hierarchical structure to said hierarchical structure construction means,

wherein said hierarchical structure construction means is in response to an instruction from said handler such that a plurality of objects from among the objects disposed at a predetermined hierarchy are designated and the plurality of objects are rearranged on the lower-order hierarchy by one stage, and rearranges the plurality of objects on the lower-order hierarchy by one stage, and produces and arranges an object including the plurality of objects on the predetermined hierarchy in such a manner that a coupling structure among the plurality of objects and a coupling structure among the plurality of objects and objects other than the plurality of objects are maintained.

If it is permitted, as in the present invention described above, that a plurality of objects is rearranged in a different hierarchy while the wiring (coupling relation) is kept as it is, it is possible to rearrange a program while the program is made up. Further, since the part replaced by a hierarchy serves as one object, it is possible to reuse the object of interest as a program part.

To attain the above-mentioned object, according to the present invention, there is provided a fourth object-oriented programming supporting apparatus for coupling



wherein said display means has, in case of existence of a plurality of method terminals connected to one message terminal designated in accordance with an instruction through said handler, means for displaying a list indicative of an execution sequence of a plurality of methods associated with the plurality of method terminals, and

said object coupling means has means for reconstructing a coupling structure in which the execution sequence of the plurality of methods appearing at the list displayed on said display means are altered in accordance with an instruction by said handler.

According to the fourth object-oriented programming supporting apparatus, it is possible to readily and exactly know an execution sequence of a plurality of methods for one message, and also possible to readily alter the execution sequence.

As to the object-oriented programming supporting apparatuses, there exists a fifth object-oriented programming supporting apparatus. The fifth object-oriented programming supporting apparatus will be described later.

To attain the above-mentioned object, according to the present invention, there is provided a first program storage medium for use in an object-oriented programming, the program storage medium being adapted for storing therein a

program to support an object-oriented programming for coupling a plurality of objects, each having data and operations, with one another,

wherein each of said objects is represented by a block representative of a main frame of an object, a data output terminal for transferring data of the object to another object, a data input terminal for receiving data from another object, a message terminal for issuing a message to make a request for processing to another object, and a method terminal for receiving a processing request from another object to execute a method, the object being represented by a hierarchical structure which permits one or a plurality of objects to exist in a single object, and an instruction for coupling terminals of the plurality of objects through a wiring is given,

said program includes: object coupling means for constructing a coupling structure among a plurality of objects in accordance with the instruction for coupling terminals of the plurality of objects through a wiring; and hierarchical structure construction means for constructing a hierarchical structure of objects, and

said program storage medium stores such a program that said hierarchical structure construction means has means for producing a duplicate object of a substantial object

designated in accordance with an instruction from said handler, and for disposing the duplicate object at a hierarchy different from a hierarchy at which the substantial object is disposed, and said object coupling means receives from said handler an instruction as to a wiring between the duplicate object and another object in the wiring of the hierarchical structure in which the duplicate object is disposed, and constructs a coupling structure in which the duplicate object and the associated substantial object are provided in the form of a united object.

To attain the above-mentioned object, according to the present invention, there is provided a second program storage medium for use in an object-oriented programming, the program storage medium being adapted for storing therein a program to support an object-oriented programming for coupling a plurality of objects, each having data and operations, with one another,

wherein each of said objects is represented by a block representative of a main frame of an object, a data output terminal for transferring data of the object to another object, a data input terminal for receiving data from another object, a message terminal for issuing a message to make a request for processing to another object, and a method terminal for receiving a processing request from



another object to execute a method, the object being represented by a hierarchical structure which permits one or a plurality of objects to exist in a single object, and an instruction for coupling terminals of the plurality of objects through a wiring is given,

said program includes: object coupling means for constructing a coupling structure among a plurality of objects in accordance with the instruction for coupling terminals of the plurality of objects through a wiring; and hierarchical structure construction means for constructing a hierarchical structure of objects, and

said program storage medium stores such a program that said object coupling means releases a coupling structure of the object before a replacement with another object in accordance with an instruction for the replacement of objects, and causes the object after the replacement to succeed to the coupling structure of the object before the replacement with another object, and said hierarchical structure construction means disposes the object after the replacement, instead of the object before the replacement, at a hierarchy at which the object before the replacement is disposed.

To attain the above-mentioned object, according to the present invention, there is provided a third program

storage medium for use in an object-oriented programming, the program storage medium being adapted for storing therein a program to support an object-oriented programming for coupling a plurality of objects, each having data and operations, with one another,

wherein each of said objects is represented by a block representative of a main frame of an object, a data output terminal for transferring data of the object to another object, a data input terminal for receiving data from another object, a message terminal for issuing a message to make a request for processing to another object, and a method terminal for receiving a processing request from another object to execute a method, the object being represented by a hierarchical structure which permits one or a plurality of objects to exist in a single object, and an instruction for coupling terminals of the plurality of objects through a wiring is given,

said program includes: object coupling means for constructing a coupling structure among a plurality of objects in accordance with the instruction for coupling terminals of the plurality of objects through a wiring; and hierarchical structure construction means for constructing a hierarchical structure of objects, and

said program storage medium stores such a program

that said hierarchical structure construction means is in response to an instruction such that a plurality of objects from among the objects disposed at a predetermined hierarchy are designated and the plurality of objects are rearranged on the lower-order hierarchy by one stage, and rearranges the plurality of objects on the lower-order hierarchy by one stage, and produces and arranges an object including the plurality of objects on the predetermined hierarchy in such a manner that a coupling structure among the plurality of objects and a coupling structure among the plurality of objects and objects other than the plurality of objects are maintained.

To attain the above-mentioned object, according to the present invention, there is provided a fourth program storage medium for use in an object-oriented programming, the program storage medium being adapted for storing therein a program to support an object-oriented programming for coupling a plurality of objects, each having data and operations, with one another,

wherein each of said objects is represented by a block representative of a main frame of an object, a data output terminal for transferring data of the object to another object, a data input terminal for receiving data from another object, a message terminal for issuing a message to

make a request for processing to another object, and a method terminal for receiving a processing request from another object to execute a method, the object being represented by a hierarchical structure which permits one or a plurality of objects to exist in a single object, and an instruction for coupling terminals of the plurality of objects through a wiring is given,

said program includes: object coupling means for constructing a coupling structure among a plurality of objects in accordance with the instruction for coupling terminals of the plurality of objects through a wiring; and hierarchical structure construction means for constructing a hierarchical structure of objects, and

said program storage medium stores such a program that said object coupling means has, in case of existence of a plurality of method terminals connected to one message terminal designated, means for making up a list indicative of an execution sequence of a plurality of methods associated with the plurality of method terminals, and means for reconstructing a coupling structure in which the execution sequence of the plurality of methods is altered in accordance with an alteration instruction of the execution sequence of the plurality of methods appearing at the list.

Of component storage mediums according to the present

invention, there is provided a first component storage medium for storing a component which serves as one object in combination with a predetermined existing software, said component including a method of issuing an event of the predetermined existing software through a firing by a message issued in other object.

According to such a component, there is provided such a form that an existing software is "included" or "involved", and thus it possible to take in an existing software in the form of an object, regardless of a structure of the existing software, or without a modification of the existing software, thereby specially improving a reuse of the existing software.

In this case, it is preferable that said component further includes together with said method a message for informing other object of that said event is issued through executing said method.

This feature makes it possible to perform an operation on a linking basis by a coupling between the method and the message.

Of component storage mediums according to the present invention, there is provided a second component storage medium for storing a component which serves as one object in combination with a predetermined existing software, said component including a message for informing other object,



another object and issues the event, and serving, when making of a message is instructed by an operation of said first handler and an issue of a predetermined event of the existing software is instructed by an operation of said second handler, in response to an occurrence of the event, to make on the component a message for informing other objects of the fact that the event occurred.

The use of the component builder apparatus mentioned above makes it possible to easily build on an interactive basis the components to be stored in the above-mentioned first and second component storage mediums, without a requirement of a deep knowledge as to a programming for operators or users.

To attain the above-mentioned object, according to the present invention, of the object-oriented programming supporting apparatuses, there is provided a fifth object-oriented programming supporting apparatus comprising:

a component file for storing therein a component which serves as one object in combination with a predetermined existing software, said component including a method of issuing an event of the predetermined existing software through a firing by a message issued in other object, and a message for informing other object of that the event is issued through executing said method, and said

component being stored in said component file with respect to one or more existing softwares;

a handler for inputting an instruction of an issue of the event as to the existing software;

an event log file for storing a list for the events as to one or more existing softwares, which are sequentially issued in accordance with an operation of said handler; and

a component coupling means for taking out sequentially the events from said event log file to combine a message of a component including the message for informing other object of that the same event as that taken out before is issued and a method of a component including the method of issuing the same event as that taken out now.

According to the fifth object-oriented programming supporting apparatus, a sequential indication of an issue of a plurality of events of one or more existing softwares in the sequence of an actual operation desired may couple the message and the method between objects "involving" the existing softwares in the components. Thus, it is possible to implement an automatic operation of a plurality of events of the existing software.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective illustration of a computer



system including an object-oriented programming apparatus according to an embodiment of the present invention;

Fig. 2 is a block diagram of an object ware programming system implemented in the computer system shown in Fig. 1;

Fig. 3 is a typical illustration showing a first example of a software system implemented within the computer system shown in Fig. 1;

Fig. 4 is a typical illustration showing an example of a data structure of an output instruction bus portion of an object A and an input instruction bus portion of an object B shown in Fig. 3;

Figs. 5 (A) and (B) are flowcharts useful for understanding <sup>processing for</sup> ~~processings for~~ an issue of a message;

Fig. 6 is a flowchart useful for understanding processings of an output instruction bus portion generating unit of an object coupling unit shown in Fig. 3;

Fig. 7 is a flowchart useful for understanding processings of an input instruction bus portion generating unit of an object coupling unit shown in Fig. 3;

Fig. 8 is a flowchart useful for understanding processings of an instruction coupling unit of an object coupling unit shown in Fig. 3;

Fig. 9 is a typical illustration showing an example

of a data structure of a data element list of <sup>the</sup> ~~an~~ object A shown in Fig. 3;

Fig. 10 is a flowchart useful for understanding processings of a data element list generating unit of <sup>the</sup> ~~an~~ object coupling unit shown in Fig. 3;

Fig. 11 is a typical illustration showing an example of a data structure of a pointer element list of <sup>the</sup> ~~an~~ object B shown in Fig. 3;

Fig. 12 is a flowchart useful for understanding processings of a pointer element list generating unit of <sup>the</sup> ~~an~~ object coupling unit shown in Fig. 3;

Fig. 13 is a typical illustration showing a structure after an execution of processings of a data coupling unit of <sup>the</sup> ~~an~~ object coupling unit shown in Fig. 3;

Fig. 14 is a flowchart useful for understanding processings of a data coupling unit of <sup>the</sup> ~~an~~ object coupling unit shown in Fig. 3;

Fig. 15 is a typical illustration showing a second example of a software system implemented within the computer system shown in Fig. 1;

Fig. 16 is a typical illustration showing a third example of a software system implemented within the computer system shown in Fig. 1;

Fig. 17 is a typical illustration showing a fourth

example of a software system implemented within the computer system shown in Fig. 1;

Fig. 18 is a typical illustration showing a fifth example of a software system implemented within the computer system shown in Fig. 1;

Fig. 19 is a typical illustration showing a part of the data structure of objects A shown in Figs. 15 to 18;

Fig. 20 is a flowchart useful for understanding an example of processing\$ for ~~an~~ issue of a message of an object A;

Fig. 21 is a flowchart useful for understanding a first example of a partial processing ~~of processings~~ of an object B;

Fig. 22 is a flowchart useful for understanding a second example of a partial processing ~~of processings~~ of an object B;

Fig. 23 is a flowchart useful for understanding a third example of a partial processing ~~of processings~~ of an object B;

Fig. 24 is a flowchart useful for understanding a fourth example of a partial processing ~~of processings~~ of an object B;

Fig. 25 is a flowchart useful for understanding a fifth example of a partial processing ~~of processings~~ of an

object B;

Fig. 26 is a flowchart useful for understanding a sixth example of a partial processing ~~of processings~~ of an object B;

Fig. 27 is a flowchart useful for understanding another example of processings for ~~an~~ issue of a message of an object A, which is different from the example of that shown in Fig. 20;

Fig. 28 is a flowchart useful for understanding a seventh example of a partial processing ~~of processings~~ of an object B;

Fig. 29 is a flowchart useful for understanding a eighth example of a partial processing ~~of processings~~ of an object B;

Fig. 30 is a flowchart useful for understanding a ninth example of a partial processing ~~of processings~~ of an object B;

Fig. 31 is a flowchart useful for understanding a tenth example of a partial processing ~~of processings~~ of an object B;

Fig. 32 is a flowchart useful for understanding processings of an input instruction tag table generating unit of an object coupling unit shown in Fig. 15;

Fig. 33 is a flowchart useful for understanding

processings of an output instruction tag table generating unit of an object coupling unit shown in Fig. 16;

Fig. 34 is a flowchart useful for understanding processings of an input data tag table generating unit of an object coupling unit shown in Fig. 17;

Fig. 35 is a flowchart useful for understanding processings of an output data tag table generating unit of an object coupling unit shown in Fig. 18;

Fig. 36 is a typical illustration of a display screen useful for understanding an object-between-network display method according to an embodiment of the present invention;

Fig. 37 is an explanatory view useful for understanding hierarchical networks;

Figs. 38(A) and <sup>38</sup>(B) are illustrations each showing by way of example a display image consisting of a lot of objects and wirings;

Figs. 39(A) and <sup>39</sup>(B) are illustrations each showing by way of example a display image of a subnetwork;

Figs. 40(A) and <sup>40</sup>(B) are illustrations each showing an alternative embodiment of the display method of the subnetwork;

Figs. 41(A), <sup>41</sup>(B) and <sup>41</sup>(C) are illustrations each showing by way of example a display image having a display area in which a plurality of measures are coupled with each

other;

Fig. 42 is an illustration showing by way of example a display image characterized by a display method of wiring;

Figs. 43(A) and <sup>43</sup>(B) are illustrations each showing an alternative embodiment of the display method of the wiring;

Figs. 44(A), <sup>44</sup>(B) and <sup>44</sup>(C) are illustrations useful for understanding a procedure for producing a display area for displaying a network of an object;

Fig. 45 is an illustration showing a state in which an object is disposed on a display screen by users;

Figs. 46(A) and <sup>46</sup>(B) are illustrations each showing a state in which a wiring among objects disposed on a display screen is performed by users;

Figs. 47(A) and <sup>47</sup>(B) are illustrations showing by way of example display screens of an object-between-network before and after display of the subnetwork, respectively;

Fig. 48 is a flowchart useful for understanding a procedure for switching from the display of Fig. 47(A) to the display of Fig. 47(B);

Figs. 49(A), <sup>49</sup>(B) and <sup>49</sup>(C) are explanatory views useful for understanding a procedure of a subnetwork display;

Fig. 50 is a flowchart useful for understanding a procedure of the subnetwork display;

Figs. 51(A), <sup>51</sup>(B) and <sup>51</sup>(C) are typical illustrations

each showing an embodiment in which a display area representative of an object is formed with a single measure or a plurality of measures coupled with one another;

Figs. 52(A) and <sup>52</sup>(B) are illustrations useful for understanding by way of example a display method of wiring;

Fig. 53 is a typical illustration showing by way of example a display of wiring;

Fig. 54 is a flowchart useful for understanding a procedure of executing the wiring shown in Fig. 53;

Fig. 55 is a flowchart useful for understanding an alternative embodiment of a procedure of executing the wiring;

Fig. 56 is a flowchart useful for understanding a further alternative embodiment of a procedure of executing the wiring;

Fig. 57 is a flowchart useful for understanding a still further alternative embodiment of a procedure of executing the wiring;

Figs. 58-62 are typical illustrations each showing a result obtained from an execution of wiring according to the wiring procedures shown in Figs. 54-56; and

Figs. 63(A), <sup>63</sup>(B) and <sup>63</sup>(C) are typical illustrations each showing a result obtained from an execution of wiring according to the wiring procedures shown in Figs. 55-57.

Fig. 64 is a schematic diagram showing a basic structure of an object-oriented programming supporting apparatus and a program storage medium for use in an object-oriented programming according to an embodiment of the present invention;

Fig. 65 is a conceptual view showing exemplarily an involving relation among objects;

Fig. 66 is a typical illustration showing a connecting relation among objects for defining a hierarchical structure;

Fig. 67 is a typical illustration showing a pointer for determining a connecting relation of a certain object to another object;

Fig. 68 is a typical illustration showing one of the bus elements constituting the bus element list to be connected to the "pointers to buses" shown in Fig. 67;

Fig. 69 is a typical illustration showing one of the cable elements constituting the cable element list to be connected to the "pointers to cables" shown in Fig. 67;

Fig. 70 is a typical illustration showing exemplarily a wiring among objects;

Fig. 71 is a conceptual view of a duplicate object;

Fig. 72 is a typical illustration showing a hierarchical structure (object tree) of the objects shown in







methods;

Fig. 94 is a typical illustration showing a cable list element list;

Fig. 95 is a view exemplarily showing a cable list displayed on a display screen 102a;

Fig. 96 is a typical illustration showing a state in which an arrangement sequence of the cable elements arranged on the cable element list is altered;

Fig. 97 is a typical illustration showing a cable element list in which an arrangement sequence of the cable elements has been altered;

Fig. 98 is a typical illustration showing a state in which an arrangement sequence of the cable list elements arranged on the cable list element list is altered;

Fig. 99 is a typical illustration showing a cable list element list in which an arrangement sequence of the cable list elements has been altered;

Fig. 100 is a view showing a cable list in which an arrangement sequence has been altered;

Fig. 101 is a typical illustration showing an embodiment of a component "including" an existing software having a graphical user interface;

Fig. 102 is a typical illustration showing an alternative embodiment of a component "including" an

existing software having a graphical user interface;

Fig. 103 is a typical illustration showing a further alternative embodiment of a component "including" an existing software having a graphical user interface;

Fig. 104 is a typical illustration showing a structure of an event processing portion of the window management section shown in Fig. 103;

Fig. 105 is a typical illustration showing a structure of an event monitor portion of the component A shown in Fig. 103;

Fig. 106 is a basic construction view of a component builder apparatus according to the present invention;

Fig. 107 is a typical illustration of an embodiment of a component builder apparatus according to the present invention;

Fig. 108 is a flowchart useful for understanding processings of building a component using a component builder apparatus;

Fig. 109 is a construction view of an object ware programming system in which structural elements corresponding to the embodiment of the fifth object-oriented programming supporting apparatus according to the present invention are added to the object ware programming system shown in Fig. 2;

Fig. 110 is a flowchart useful for understanding an

operation of a component coupling unit;

Fig. 111 is a flowchart useful for understanding an operation of a component coupling unit;

Fig. 112 is a conceptual view showing a state in which an existing software is "included" in a component;

Fig. 113 is a view showing a table for definition items to give various definitions shown in Fig. 112; and

Fig. 114 is a view exemplarily showing images displayed on a display screen 102a when definitions are given.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, there will be described embodiments of the present invention.

First, there will be explained an outline of an object ware programming system in which embodiments according to the present invention are put together, and then each individual embodiment will be explained.

Fig. 1 is a perspective illustration of a computer system including each individual embodiment of the present invention of an object-oriented programming apparatus, an object-oriented programming supporting apparatus, a component builder apparatus, an object-oriented program storage medium, a program storage medium for use in an object-oriented programming, a component storage medium, and

# DEVELOPE

A development of programs can be implemented by the computer system 100 shown in Fig. 1. It is acceptable that programs, which are developed by another same type of computer system, are stored in a portable type of recording medium such as an MO (magneto-optical disc) 110, and the MO 110 is loaded into the computer system 100 shown in Fig. 1 so that the developed programs can be inputted into the computer system 100. Likewise, it is possible to transfer the programs developed with the use of the computer system 100 shown in Fig. 1 through the MO 110 to another computer system.

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in Fig. 1.

An object ware programming system 120 comprises an object builder unit 121 for building objects and/or a component which "includes" existing softwares, an interobject wiring editor unit 122 for displaying a wiring among objects (a coupling relation) to perform an editing, and an interpreter unit 123 for connecting and running objects (including an object consisting of a combination of the existing software and the component), which are generated in the object builder unit 121, in accordance with the wiring among objects, or the coupling relation, which is defined by the interobject wiring editor unit 122.

While the object builder unit 121 can build directly an object through an operation of the keyboard 103 or the mouse 104 in the computer system 100 shown in Fig. 1, the object ware programming system 120 is provided with an existing application file 131 for storing existing various types of application programs (hereinafter, it may happen that the application program is referred to simply as an application), which have been developed with various types of program languages. And thus the object builder unit 121 may also build a component which serves as one object, "involving" the existing application stored in the existing application file 131, together with the existing application.

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It is to be noted that the object is expressed including an object consisting of a combination of the above-mentioned component and the existing application "involved" in the component, unless we note the particular.

The object built in the object builder unit 121 is stored in an object data file 132 and a running object file 133. The object data file 132 stores therein, of data representative of the object built in the object builder unit 121, data necessary for a display of objects and a wiring (definition of the coupling relation) among objects. On the other hand, the running object file 133 stores therein running objects in which the object built in the object builder unit 121 is converted into a running format of one.

The interobject wiring editor unit 122 displays, upon receipt of data as to an object stored in the object data file 132, the object on the display screen 102a of the image display unit 102 shown in Fig. 1, and defines a coupling state among objects in accordance with an operation of the keyboard 103 or the mouse 104. As will be described, a display on the display screen 102a is given with a display style close to that of an LSI (Large Scale Integrated Circuit) as the hardware, and a definition of the coupling state among objects is performed in such a sense that terminals of such a plurality of LSI's are wired by signal



lines. Hence, hereinafter, it may happen that the object is referred to as "LSI", and a definition of the coupling state among objects is referred to as "wiring".

When a wiring among objects is performed by the interobject wiring editor unit 122, an interobject wiring data file 134 is used for the purpose of saving an intermediate result of the wiring and displaying the intermediate result through loading. The interobject wiring data file 134 stores wiring information which is convenient as a man-machine interface. For example, in the system according to present embodiment, there is provided a hierarchical structure of objects for the purpose of easy understanding of wiring for users. The interobject wiring data file 134 stores also data as to such a hierarchical structure.

In this manner, when the interobject wiring editor unit 122 has completed the wiring, an interpreter use wiring data file 135 stores information (hereinafter, it is referred to as "wiring data") representative of a coupling state among objects. When the interpreter use wiring data file 135 stores the wiring data, information simply available for user's understanding, for example, information of the hierarchical structure of objects, is omitted, and only the wiring data, which is necessary for actuation of the object

(software), is extracted and stored in the interpreter use wiring data file 135.

In the interpreter unit 123, the running objects stored in the running object file 133 are coupled and executed in accordance with the wiring data stored in the interpreter use wiring data file 135.

Hereinafter, the respective embodiments will be described. As a matter of convenience of explanation and for better understanding of the invention, there will be described, taking into account of the arrangement of the object ware programming system 120 shown in Fig. 2, first, the embodiment concerning the interpreter unit 123 and the associated periphery, then the embodiment concerning the interobject wiring editor unit 122 and the associated periphery, and finally the embodiment concerning the object builder unit 121 and the associated periphery.

First, there will be described the embodiment concerning the interpreter unit 123 and the associated periphery.

Fig. 3 is a typical illustration showing a first example of a software system implemented within the computer system shown in Fig. 1. Now referring to Fig. 3, there will be described a schematic construction of a first object-oriented programming apparatus and a first

object-oriented program storage medium according to one embodiment of the present invention, and then referring to Fig. 4 et <sup>seq.</sup> ~~seq.~~ there will be described details of those.

A corresponding relation between the software system shown in Fig. 3 and the present invention is as follows. That is, the storage unit 105 (~~cf.~~ Fig. 1), in which the software system shown in Fig. 3 is stored, corresponds to the first object-oriented program storage medium according to an embodiment of the present invention, and a combination of the hardware of the computer system 100 shown in Fig. 1 and an object coupling unit 10 which is in a state operable under the computer system 100 corresponds to the first object-oriented programming apparatus. Incidentally, when the software system shown in Fig. 3 is downloaded onto the MO 110, the MO 110 also corresponds to an example of the first object-oriented program storage medium according to an embodiment of the present invention.

Now, let us consider typically two objects A and B each comprising data and processing (method).

An output instruction bus portion generating unit 11, <sup>in</sup> ~~which constitutes~~ the object coupling unit 10, generates a portion which forms a core of an output instruction bus portion for performing an issue process of a message of an object <sup>for example</sup> (~~here typically~~ object A) to another object <sup>for</sup> (~~here~~

<sup>example</sup>  
~~typically~~ object B).

An input instruction bus portion generating unit 12,  
<sup>in</sup> ~~which constitutes~~ the object coupling unit 10, generates an  
input instruction bus portion of an object (<sup>for example</sup> ~~here typically~~  
object B). The input instruction bus portion receives a  
message directed to the self object (<sup>for example</sup> ~~here typically~~ object B)  
issued by another object (<sup>for example</sup> ~~here typically~~ object A), and  
activates a method of the self object (<sup>for example</sup> ~~here typically~~ object  
B), which method is associated with the received message.

Incidentally, according to the present embodiment,  
the output instruction bus portion generating unit 11 and the  
input instruction bus portion generating unit 12 are provided  
in the object coupling unit 10. However, it is acceptable  
that the objects A and B have originally structures  
corresponding to the output instruction bus portion or the  
input instruction bus portion. Alternatively, it is  
acceptable that the object coupling unit 10 does not always  
comprise the output instruction bus portion generating unit  
11 and the input instruction bus portion generating unit 12.

An instruction coupling unit 13, <sup>in</sup> ~~which constitutes~~  
the object coupling unit 10, permits a message to be  
transferred between objects (~~typically~~ objects A and B) by  
means of giving an association of a message of the object A  
with a method of object B.

A data element list generating unit 14, <sup>in</sup> ~~which~~ ~~constitutes~~ the object coupling unit 10, generates a data element list of an object (typically object A) in which pointers to data storage areas for storing therein data are arranged.

Likewise, a pointer element list generating unit 15, <sup>in</sup> ~~which~~ ~~constitutes~~ the object coupling unit 10, generates a pointer element list of an object (typically object B) in which pointers to pointer storage areas for storing therein pointers to data are arranged.

A data coupling unit 16, <sup>in</sup> ~~which~~ ~~constitutes~~ the object coupling unit 10, permits a message to be transferred between objects A and B by means of writing pointers, which are arranged in the data element list produced by the data element list generating unit 14, into pointer storage areas indicated by the pointers arranged in the pointer element list of the object B produced by the pointer element list generating unit 15.

Fig. 4 is a typical illustration showing an example of a data structure of an output instruction bus portion of an object A and an input instruction bus portion of an object B shown in Fig. 3.

The object A has a message table consisting of an arrangement of a maximum number  $MA_{MAX}$  of messages of the

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object A. The message table stores pointers to a method element list, which will be described hereinafter, corresponding to a message number  $MA_A$  of each message (where a message number is expressed by MA and it is expressed by a suffix A that the message number is of a message of the object A).

The method element list consists of an arrangement of a single or a plurality of method elements. Each of the method elements comprises a method number ME for specifying a method, a pointer to an object in which the method specified by the method number ME is executed, and a pointer to the subsequent method element. Here, the method number is expressed by an ME, and the object in which the method specified by the method number ME is executed is expressed by a suffix. Specifically, the uppermost stage of <sup>the</sup> method element shown in Fig. 3 stores a method number  $ME_B$  of a method of the object B, and a pointer to the object B.

The last stage of method element  <sup>$ME_B$  in Fig. 3</sup> stores ~~in its column~~ of a pointer to the subsequent method element data (referred to as "null") <sup>indicating</sup> ~~indicative of~~ that the method element is of the final stage itself and there is no method element after itself.

The method element lists are generated at the maximum by a number corresponding to the number of messages of the

object A. Each of the method element lists corresponds to the associated message of the object A. When the message is issued, the associated method element list is referred to.

While a one method element list corresponds to a one message on a one-to-one basis, it is not always arranged that method elements arranged on a one method element list are <sup>the</sup> only ones related to a certain ~~one~~ object (e.g. the object B) and it is permitted that method elements related to a plurality of methods of a plurality of objects are arranged on a one method element list.

While the above-mentioned description explains a construction of the output instruction bus unit of the object A, the output instruction bus unit is provided for each of the objects which issue messages to another object.

The object B has a method table consisting of an arrangement of a maximum  $ME_B \text{ MAX}$  of a method number  $ME_B$  of the object B. The method table stores therein a pointer to the method specified by the method number  $ME_B$ , corresponding to the method number  $ME_B$  of each method.

While the above-mentioned description explains a construction of the input instruction bus unit of the object B, the input instruction bus unit receives a message issued by another object, in a similar fashion to that of the output instruction bus unit, and is provided for each of the

objects, which executes the method associated with the received message. In some cases, it happens that ~~a~~ one object has both <sup>an</sup> ~~the~~ output instruction bus unit and <sup>an</sup> ~~the~~ input instruction bus unit.

Fig. 5 is a flowchart useful for understanding processings for an issue of a message.

When it is intended to issue a message in a certain processing in execution in the object A, a message table is referred to so as to obtain, from a message number MA of the message intended to be issued, a pointer to the method element list associated with the message number MA<sub>A</sub> n ID (step 5\_1), so that the method elements arranged in the method element list indicated by the pointer are referred to. For example, when the uppermost ~~of~~ <sup>the</sup> stage of method element shown in Fig. 4 is referred to, the object-B indicated by a pointer stored in the method element referred to is called wherein a method number ME<sub>B</sub> stored in the method element serves as an argument (step 5\_2). Such a message issue processing is performed on each of the method elements arranged in a one method element list for each issue of a one message (steps 5\_3, 5\_4).

In the object B called wherein the method number ME<sub>B</sub> serves as an argument, the method number ME<sub>B</sub> given in the form of an argument is obtained (step 5\_5). In step 5\_6



there is provided such a process that the method table is referred to so as to obtain a pointer to a method specified by the obtained method number  $ME_B$ , and a processing of the method indicated by the pointer is performed.

Fig. 6 is a flowchart useful for understanding processings of an output instruction bus portion generating unit 11 of an object coupling unit 10 shown in Fig. 3.

In step 6\_1, a frame of the message table having a width  $MA_{A \text{ MAX}}$  shown in Fig. 4 is produced.

Incidentally, according to the present embodiment, it is so arranged that when the object A issues a message, a pointer of the method element list is identified through a message table. However, it is acceptable that the pointer to the method element is written directly into a process (method) of the object A, for example, and thus in this case, there is no need to provide the message table. In other words, the process shown in Fig. 6, or the output instruction bus portion generating unit 11 shown in Fig. 3 is not always needed.

Fig. 7 is a flowchart useful for understanding processings of an input instruction bus portion generating unit 12 of an object coupling unit 10 shown in Fig. 3.

In step 7\_1, a frame of the method table having a width  $ME_B \text{ MAX}$  shown in Fig. 4 is produced. And in step 7\_2,

a pointer to the method associated with the respective method number  $ME_B$  is stored in a column of the respective method number  $ME_B$  within the frame.

Incidentally, according to the present embodiment, it is so arranged that a pointer of the method is recognized through a method table. However, there <sup>maybe</sup> ~~is~~ no need to provide an association of the method number  $ME_B$  with the pointer to the method in form of the message table. Accordingly, the process shown in Fig. 7, or the input instruction bus portion generating unit 12 shown in Fig. 3 is not always needed.

Fig. 8 is a flowchart useful for understanding processings of an instruction coupling unit 13 of an object coupling unit 10 shown in Fig. 3. Here, also it is assumed that the object B is typical of another object.

When the method elements are produced, an operator, who operates the computer system shown in Fig. 1, designates a corresponding relation between a message and a method. This corresponding relation is determined by the following designations.

- (a) A pointer of the object A
- (b) A pointer of the object B
- (c) A message number  $MA_A$  of the object A
- (d) A method number  $ME_B$  of the object B

It is noted that designations of the above-noted (a)

to (d) are performed, for example, in such a manner that designations for a name of the object, a processing (e.g. "display on a screen the spreadsheet program and the spreadsheet result") and the like are performed by clicking through an operation of a mouse 104 (cf. Fig. 1), of an icon displayed on a display screen 102a. More in detail, as will be described later, objects are displayed in the form of an LSI, and a designation is performed through an operation for wiring among terminals of the LSI's using the mouse 104.

In the processing shown in Fig. 8, first, a frame of the method element is produced (step 8\_1). In step 8\_2, the method number  $ME_B$  and the pointer of the object B are stored in the frame of the method element, so that they are added to the method element list of the associated message number  $MA_A$  (step 8\_3). That is, the pointer to the method element to be added is stored in the column of the pointer to the next method element, of the last stage of method element arranged in the method element list, and the "null" is stored in the column of the pointer to the next method element, of the method element to be added. The processing shown in Fig. 8 is repeatedly performed, if necessary, to produce the method element list.

Incidentally, when none of method element is arranged in the method element list, according to the present

embodiment, a pointer to a method element intended to be registered is stored in the column of the associated message number  $MA_A$ , of the message table.

According to the present embodiment, producing the method element list in the manner as mentioned above may provide an association of the message of the object A with the method of the object B. This feature makes it possible for an operator to easily grasp a corresponding relation between the message and the method so as to readily recognize the method associated with the message, thereby implementing a high speed processing.

Fig. 9 is a typical illustration showing an example of a data structure of a data element list of an object A shown in Fig. 3.

The object A includes a lot of data (e.g. n pieces of data) to be transferred to the object B. The data element list generating unit 14 of the object coupling unit 10 shown in Fig. 3 produces the data element lists shown in Fig. 8.

In the data element list, there are arranged the data elements<sup>9</sup>, the number of which corresponds to the number of data (n pieces of data). Each of the data elements comprises a pointer to a data storage area for storing therein data, and a pointer to the subsequent data element. The "null" is written into the column of the pointer to the subsequent data

the  
A element, of <sup>A</sup> the last stage of data element. Incidentally, in  
Fig. 9, for example, the pointer associated with the data  
storage area 1 is denoted by a pointer 1\_1 but not a pointer  
1. The reason <sup>this is done is so</sup> ~~why it is to do so~~ is that such a pointer is  
A distinguished from a pointer which will be described later.

An "OUT<sub>A</sub>" in Fig. 9 denotes a data element list  
number. As to the data element lists, there is such a  
possibility that a large number of data element lists are  
produced in accordance with a number of destinations to which  
data are transferred. Here, the data element lists are  
discriminated from one another by the data element list  
number "OUT<sub>A</sub>" (where the suffix A denotes the object A).

Fig. 10 is a flowchart useful for understanding  
processings of a data element list generating unit 14 of an  
object coupling unit 10 shown in Fig. 3.

In order to produce a data element list, first, a  
frame of data elements is produced (step 10\_1). A pointer to  
a data storage area is substituted into the frame (step 10\_  
2). In step 10\_3, the pointer to the data storage area is  
added to the data element list. When the pointer to the data  
storage area is added to the data element list, the pointer  
to the data element list to be added is stored in the column  
of the pointer to the next data element, of the data element  
arranged in the last stage of the data element list, and the

"null" is stored in the column of the pointer to the next data element, of the data element list to be added.

The processing shown in Fig. 10 is repeatedly performed, if necessary, to produce the data element list.

Fig. 11 is a typical illustration showing an example of a data structure of a pointer element list of an object B shown in Fig. 3.

The object B includes a lot of segments (e.g. n pieces of segments) needed to receive data from the object A. Each of the segments has the associated pointer storage area. The pointer storage areas 1 to n store, at the stage before data elements are coupled with pointer elements, arbitrary pointers to data, 1\_3, 2\_3, ..., n\_3, respectively. The pointer element list generating unit 15 of the object coupling unit 10 shown in Fig. 3 produces the pointer element list shown in Fig. 11.

In the pointer element list, there are arranged the pointer elements the number of which corresponds to the number of pointer storage areas (n pieces of area). Each of the pointer elements comprises a pointer to the associated pointer storage area, and a pointer to the subsequent pointer element. Incidentally, in Fig. 11, for example, the pointer to the pointer storage area 1 is denoted by a pointer 1\_2 but not a pointer 1, and an arbitrary pointer stored in the

pointer storage area 1 is denoted by a pointer 1\_3. The <sup>this is done is so</sup> reason ~~why it is to do so~~ is that the pointers <sup>in Fig. 11 and</sup> ~~including the~~ pointers stored in the data elements shown in Fig. 9 <sup>can be</sup> ~~are~~ distinguished from one another.

As to the pointer element lists also, in a similar fashion to that of the data element lists, there is such a possibility that a large number of pointer element lists are produced in accordance with a number of sinks which receive data. Here, the pointer element lists are discriminated from one another by a pointer element list number "IN<sub>B</sub>" (where the suffix B denotes the object B).

Fig. 12 is a flowchart useful for understanding processings of a pointer element list generating unit 15 of an object coupling unit 10 shown in Fig. 3. This processing is similar to the processing of the data element list generating unit 14, which processing is shown in Fig. 10. Thus, the redundant description will be omitted.

First, a frame of pointer elements is produced (step 12\_1). A pointer to the associated pointer storage area is stored in the frame (step 12\_2). In step 12\_3, the pointer to the associated pointer storage area is added to the pointer element list. The processing shown in Fig. 12 is repeatedly performed, if necessary, to produce the pointer element list.

Fig. 13 is a typical illustration showing a structure after an execution of processings of a data coupling unit 16 of an object coupling unit 10 shown in Fig. 3.

Pointer storage areas 1 to n of the object B store therein pointers 1\_1 to n\_1 stored in the data elements arranged in the data element lists shown in Fig. 9, respectively. This structure permits the object B to directly refer to data of the object A.

Fig. 14 is a flowchart useful for understanding processings of a data coupling unit 16 of an object coupling unit 10 shown in Fig. 3.

In step 14\_1, the pointer 1\_1 stored in the data element arranged in the head of the data element list shown in Fig. 9 is stored in a working area D. Likewise, in step 14\_2, the pointer 1\_2 stored in the pointer element arranged in the head of the pointer element list shown in Fig. 11 is stored in the working area D.

Next, in step 14\_3, it is determined whether the working area D is empty, in other words, it is determined whether a mapping, which will be described on step 14\_5, is completed up to the last stage of data element arranged in the data element list shown in Fig. 9. When the working area D is empty, the processing shown in Fig. 14 is terminated.



Likewise, in step 14\_4, it is determined whether a working area P is empty, in other words, it is determined whether a mapping is completed up to the last stage of pointer element arranged in the pointer element list shown in Fig. 11. When the working area P is empty, the processing shown in Fig. 14 is terminated.

In step 14\_5, a pointer (e.g. pointer 1\_1 shown in Fig. 9) stored in the working area D is substituted for a pointer (e.g. pointer 1\_3) stored in the pointer storage area (e.g. pointer storage area 1) indicated by a pointer (e.g. pointer 1\_2 shown in Fig. 11) stored in the working area P. Thus, there is provided a mapping or a correspondence between the data 1 of the object A and the pointer 1\_1 of the object B, which mapping is shown in Fig. 13.

In step 14\_6, a pointer (e.g. pointer 2\_1) stored in the next data element arranged in the data element list shown in Fig. 9 is stored in the working area D. Likewise, a pointer (e.g. pointer 1\_2) stored in the next pointer element arranged in the pointer element list shown in Fig. 11 is stored in the working area P. And the process returns to the step 14\_3. In this manner, this routine is repeated. Again in step 14\_5, when there is provided a mapping between the last stage of data element of the data element list shown in Fig. 9 and the last stage of pointer element of the pointer

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element list shown in Fig. 11, the process goes to the step 14\_6 in which the working areas D and P are reset to be empty. And the process returns to the step 14\_3 and the processing shown in Fig. 14 is terminated. While the above-explanation was made assuming that the number of the data elements arranged in the data element list is the same as the number of pointer elements of the pointer element list, when they are different from one another in the number, the working areas D or P are reset to be empty at the time when a mapping for one less in number is terminated, and then the processing of Fig. 14 is terminated.

After the processing of Fig. 14 or the mapping between the data element list and the pointer element list is terminated, the data element list and the pointer element list become useless and thus be erased.

In the data coupling processing explained in conjunction with Figs. 9 to 14, an operator, who operates the computer system 100, inputs:

- (a) A pointer of the object A;
- (b) A pointer of the object B;
- (c) A data element list number  $OUT_A$  of the object A;
- (d) A pointer element list number  $IN_A$  of the object B.

It is noted that an input of data of the above-noted items (a) to (d) are performed, in a similar fashion to that

of the input of the corresponding relation between the message and the method explained referring to Fig. 8, by clicking of an icon displayed on a display screen 102a (cf. Fig. 1).

In the processing shown in Fig. 14, while the mapping between the data elements arranged in the data element list and the pointer elements arranged in the pointer element list is performed in accordance with the sequence of their arrangements, for example, when the objects A and B are made up, a provision of such a rule that the same name or the associated name is given for the data storage area and the pointer storage area which are associated with one another, or such a rule that there is provided an arrangement of the same or associated names in such a manner that the associated one-to-one are arranged in the same sequence makes it possible to generate, by referring to their names or the sequences of the arrangements, the data element list and the pointer element list in which the data elements and the pointer elements, which are associated with one another, respectively, are arranged in the same sequence in their lists, respectively. Thus, it is possible to provide the mapping associated with the arrangement sequence as shown in Fig. 14.

According to the present embodiment, as shown in Fig.



apparatuses according to embodiments of the present invention and the second to fifth object-oriented program storage medium according to embodiments of the present invention, and thereafter referring to Figs. 19 to 35, there will be described embodiments in which the second to fifth object-oriented programming apparatuses according to embodiments of the present invention and the second to fifth object-oriented program storage medium according to embodiments of the present invention are put together, respectively.

Fig. 15 is a typical illustration showing a second example of a software system implemented within the computer system shown in Fig. 1.

A corresponding relation between the software system shown in Fig. 15 and the present invention is as follows.

That is, the storage unit 105 (cf. Fig. 1), in which the software system shown in Fig. 15 is stored, corresponds to the second object-oriented program storage medium according to an embodiment of the present invention, and a combination of the hardware of the computer system 100 and an object coupling unit 20 which is in a state operable under the computer system 100 corresponds to the second object-oriented programming apparatus. Incidentally, when the software system shown in Fig. 15 is downloaded onto the

MO 110 shown in Fig. 1, the MO 110 also corresponds to an example of the second object-oriented program storage medium according to an embodiment of the present invention.

Also in Fig. 15, let us consider typically two objects A and B among a number of objects.

In the object coupling unit 20 shown in Fig. 15, an output instruction bus portion generating unit 21, an input instruction bus portion generating unit 22, and an instruction coupling unit 23 are the same in their processing as the output instruction bus portion generating unit 11, the input instruction bus portion generating unit 12 and the instruction coupling unit 13 of the object coupling unit 10 shown in Fig. 3, respectively. Thus, in a similar fashion to that of Fig. 3, the instruction coupling unit 23 produces a path 23a to provide an association of messages of the object A with messages of the object B. It is also similar to that of Fig. 3 that the output instruction bus portion generating unit 21 and the input instruction bus portion generating unit 22 are not always needed.

An input instruction tag table generating unit 24 produces, on the output instruction bus portion of the object A, an input instruction tag table showing a correspondence between a message of another object (here typically the object B) and a method of the object A.

As will be described later, the input instruction tag table is transferred to the object B in the form of an argument of a message issued from the object A to the object B. In the object B, during a processing of the object B there is dynamically produced a passage for an issue of a message directed from the object B to the object A, for example.

Fig. 16 is a typical illustration showing a third example of a software system implemented within the computer system shown in Fig. 1.

A corresponding relation between the software system shown in Fig. 16 and the present invention is as follows.

That is, the storage unit 105 (cf. Fig. 1), in which the software system shown in Fig. 16 is stored, corresponds to the third object-oriented program storage medium according to an embodiment of the present invention, and a combination of the hardware of the computer system 100 and an object coupling unit 30 which is in a state operable under the computer system 100 corresponds to the third object-oriented programming apparatus. Incidentally, when the software system shown in Fig. 16 is downloaded onto the MO 110 shown in Fig. 1, the MO 110 also corresponds to an example of the third object-oriented program storage medium according to an embodiment of the present invention.

Also in Fig. 16, let us consider typically two objects A and B among a number of objects.

In the object coupling unit 30 shown in Fig. 16, an output instruction bus portion generating unit 31, an input instruction bus portion generating unit 32, and an instruction coupling unit 33 are the same in their processing as the output instruction bus portion generating unit 11, the input instruction bus portion generating unit 12 and the instruction coupling unit 13 of the object coupling unit 10 shown in Fig. 3, respectively. Thus, in a similar fashion to that of Fig. 3, the instruction coupling unit 33 produces a path 33a to provide an association of messages of the object A with messages of the object B. It is also similar to that of Fig. 3 that the output instruction bus portion generating unit 31 and the input instruction bus portion generating unit 32 are not always needed.

An output instruction tag table generating unit 34 produces, on the output instruction bus portion of the object A, an output instruction tag table showing a correspondence between a method of another object (here typically the object B) and a message of the object A.

As will be described later, the output instruction tag table is transferred to the object B in the form of an argument of a message issued from the object A to the object



B. In the object B, during a processing of the object B there is dynamically rearranged a passage for an issue of a message directed from the object A to the object B, for example.

Fig. 17 is a typical illustration showing a fourth example of a software system implemented within the computer system shown in Fig. 1.

A corresponding relation between the software system shown in Fig. 17 and the present invention is as follows.

That is, the storage unit 105 (cf. Fig. 1), in which the software system shown in Fig. 17 is stored, corresponds to the fourth object-oriented program storage medium according to an embodiment of the present invention, and a combination of the hardware of the computer system 100 and an object coupling unit 40 which is in a state operable under the computer system 100 corresponds to the fourth object-oriented programming apparatus. Incidentally, when the software system shown in Fig. 17 is downloaded onto the MO 110 shown in Fig. 1, the MO 110 also corresponds to an example of the fourth object-oriented program storage medium according to an embodiment of the present invention.

Also in Fig. 17, let us consider typically two objects A and B among a number of objects.

In the object coupling unit 40 shown in Fig. 17, an

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output instruction bus portion generating unit 41, an input instruction bus portion generating unit 42, and an instruction coupling unit 43 are the same in their processing as the output instruction bus portion generating unit 11, the input instruction bus portion generating unit 12 and the instruction coupling unit 13 of the object coupling unit 10 shown in Fig. 3, respectively. Thus, in a similar fashion to that of Fig. 3, the instruction coupling unit 43 produces a path 43a to provide an association of messages of the object A with messages of the object B. It is also similar to that of Fig. 3 that the output instruction bus portion generating unit 41 and the input instruction bus portion generating unit 42 are not always needed.

An input data tag table generating unit 44 produces, on the output instruction bus portion of the object A, an input data tag table showing a correspondence between a data element list number  $OUT_B$  for specifying a data element list in which pointers to data storage areas of another object (here typically the object B) are arranged and a pointer element list number  $IN_A$  for specifying a pointer element list in which pointers to pointer storage areas of the object A are arranged.

The data element list number  $OUT_B$  and the pointer element list number  $IN_A$  are determined at the stages when the

objects B and A are made up, respectively. However, at the stage in which the input data tag table is simply generated, the data element list itself and the pointer element list itself are not yet produced. The input data tag table is transferred to the object B in the form of argument of a message issued from the object A to the object B. Upon receipt of the input data tag table, the object B produces a data element list of one's own (the object B) dynamically during a processing of the object B and a pointer element list of the object A as well, so that the data element list and the pointer element list are coupled together. Details thereof will be described later.

Fig. 18 is a typical illustration showing a fifth example of a software system implemented within the computer system shown in Fig. 1.

A corresponding relation between the software system shown in Fig. 18 and the present invention is as follows.

That is, the storage unit 105 (cf. Fig. 1), in which the software system shown in Fig. 18 is stored, corresponds to the fifth object-oriented program storage medium according to an embodiment of the present invention, and a combination of the hardware of the computer system 100 and an object coupling unit 50 which is in a state operable under the computer system 100 corresponds to the fifth object-oriented

programming apparatus. Incidentally, when the software system shown in Fig. 18 is downloaded onto the M0 110 shown in Fig. 1, the M0 110 also corresponds to an example of the fifth object-oriented program storage medium according to an embodiment of the present invention.

Also in Fig. 18, let us consider typically two objects A and B among a number of objects.

In the object coupling unit 50 shown in Fig. 18, an output instruction bus portion generating unit 51, an input instruction bus portion generating unit 52, and an instruction coupling unit 53 are the same in their processing as the output instruction bus portion generating unit 11, the input instruction bus portion generating unit 12 and the instruction coupling unit 13 of the object coupling unit 10 shown in Fig. 3, respectively. Thus, in a similar fashion to that of Fig. 3, the instruction coupling unit 53 produces a path 53a to provide an association of messages of the object A with messages of the object B. It is also similar to that of Fig. 3 that the output instruction bus portion generating unit 51 and the input instruction bus portion generating unit 52 are not always needed.

An output data tag table generating unit 54 produces, on the output instruction bus portion of the object A, an output data tag table showing a correspondence between a

pointer element list number  $IN_B$  for specifying a pointer element list in which pointers to pointer storage areas of another object (here typically the object B) are arranged and a data element list number  $OUT_A$  for specifying a data element list in which pointers to data storage areas of the object A are arranged.

The pointer element list number  $IN_B$  and the data element list number  $OUT_A$  are determined at the stages when the objects B and A are made up, respectively. However, at the stage in which the output data tag table is simply generated, the pointer element list itself and the data element list itself are not yet produced. The output data tag table is transferred to the object B in the form of argument of a message issued from the object A to the object B. Upon receipt of the output data tag table, the object B produces a data element list of the object A dynamically during a processing of the object B and a pointer element list of one's own (the object B) as well, so that the data element list and the pointer element list are coupled together. Details thereof will be described later.

Fig. 19 is a typical illustration showing a part of the data structure of objects A shown in Figs. 15 to 18. Fig. 19 shows, of the data structure shown in Fig. 4, one method element, an input instruction tag table, an output

instruction tag table, an input data tag table, and output data tag table, these four tag tables being coupled with the method element. Fig. 19 shows overall data structure of the embodiments having all aspects of the respective embodiments explained referring to Figs. 15 to 18.

Appended to the method element shown in Fig. 19 are the structure of the method element shown in Fig. 4, that is, a method number  $ME_B$  of another object (here typically object B), a pointer to an object (here object B) which executes a method specified by the method number  $ME_B$ , a pointer to the subsequent method element, a pointer to an input instruction tag table (hereinafter, it happens that this pointer is referred to as P1), a pointer to an output instruction tag table (hereinafter, it happens that this pointer is referred to as P2), a pointer to an input data tag table (hereinafter, it happens that this pointer is referred to as P3), a pointer to an output data tag table (hereinafter, it happens that this pointer is referred to as P4), and a pointer to oneself (object A) (hereinafter, it happens that this pointer is referred to as P5).

The input instruction tag table has the same width in its arrangement as the maximum number  $MA_{B \text{ MAX}}$  of messages of another object (here object B), and stores therein the method number  $ME_A$  of the object A in association with the message

number  $MA_B$  of the object B.

The output instruction tag table has the same width in its arrangement as the maximum number  $ME_{B \text{ MAX}}$  of method of another object (here object B), and stores therein the message number  $MA_A$  of the object A in association with the method number  $ME_B$  of the object B.

The input data tag table has the same width in its arrangement as the maximum number  $OUT_{B \text{ MAX}}$  of data element lists of another object (here object B), and stores therein the pointer element list number  $IN_A$  of the object A in association with the data element list number  $OUT_B$  of the object B.

The output data tag table has the same width in its arrangement as the maximum number  $IN_{B \text{ MAX}}$  of pointer element lists of another object (here object B), and stores therein the data element list number  $OUT_A$  of the object A in association with the pointer element list number  $IN_B$  of the object B.

Incidentally, while Fig. 19 shows, with respect to the output instruction bus portion of the object A, four tag tables related to the object B, generally, these four tag tables are provided in set by the number of party objects which receive messages issued by the object A, when the output instruction bus portion of the object A is viewed as a

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whole. That is, these four tag tables are provided in association with each of the respective objects concerned. This is the similar as to the matter of the output instruction bus portion of another object not limited to the object A.

In the event that the object A issues messages to the object A referring to the method element shown in Fig. 19, transferred from the object A are the method number  $ME_B$  of the object B and in addition, if necessary, part or all of the pointers P1- P5 in the form of arguments. Alternatively, it is acceptable that the method number  $ME_B$  and all of the pointers P1- P5 are always transferred in the form of arguments.

Hereinafter, so far as it is not noted specifically, the explanation will be made presupposing the data structure in which the data structure shown in Fig. 4 has been altered as shown in Fig. 19.

Fig. 20 is a flowchart useful for understanding an example of processings for an issue of a message of an object A.

In Fig. 20, the steps 20\_1, 20\_3 and 20\_4 are the same as the steps 5\_1, 5\_3 and 5\_4 of Fig. 5, respectively. Thus, the redundant explanation will be omitted.

In step 20\_2, the method number  $ME_B$  and in addition



the pointers P1, P2 and P5, according to the present example, are transferred to the object B in the form of arguments. Upon receipt of the message, the object B executes a processing of a method specified by the method number  $ME_B$  in accordance with the flowchart shown in Fig. 5(B).

Fig. 21 is a flowchart useful for understanding a first example of a partial processing of processings of an object B. The partial processing is executed during a processing of a method specified by the method number  $ME_B$  transferred to the object B in the form of arguments.

In step 21\_1, referring to the input instruction tag table transferred to the object B in the form of arguments, the method number  $ME_A$  of the object A is obtained from the message number  $MA_B$  of the object B. In step 21\_2, during a processing of the object B, a processing of the method of the obtained method number  $ME_A$  of the object A is executed.

Fig. 22 is a flowchart useful for understanding a second example of a partial processing of processings of an object B.

In step 22\_1, referring to the input instruction tag table transferred to the object B in the form of arguments, the method number  $ME_A$  of the object A is obtained from the message number  $MA_B$  of the object B. In step 22\_2, a method element related to the method number  $ME_A$  of the object A is



processing at the present time in the object B.

Alternatively, it is acceptable that the object C is produced in processing at the previous or earlier time in the object B.

In the partial processing shown in Fig. 24, in step 24\_1, referring to the input instruction tag table transferred to the object B in the form of arguments, the method number  $ME_A$  of the object A, which is associated with the message number  $MA_B$  succeeded to the object C, originally the message number of the object B, is obtained. In step 24\_2, a method element of the method number  $ME_A$  of the object A is added to the method element list of the object C associated with the message number  $MA_B$  of the message table of the object C. Thus, a path of messages from the object C to the object A is formed.

Fig. 25 is a flowchart useful for understanding a fifth example of a partial processing of processings of an object B.

In step 25\_1, referring to the output instruction tag table, the message number  $MA_A$  of the object A associated with the method number  $ME_A$  of the object A is obtained. In step 25\_2, a method element related to the method number  $ME_B$  of the object B is added to a method element list associated with the message number  $MA_A$  of the message table of the object A. In this manner, thereafter, an issuance of the

message of the message number  $MA_A$  of the object A permits an execution of the method of the method number  $ME_B$  of the object B.

Fig. 26 is a flowchart useful for understanding a sixth example of a partial processing of processings of an object B.

With respect to the partial processing shown in Fig. 26, there is a need, prior to its execution, to perform the partial processing shown in Fig. 23 so that the object C is produced. However, with respect to timing of a producing of the object C, it is not restricted specifically. It is acceptable that the object C is produced during a series of processing at the present time in the object B. Alternatively, it is acceptable that the object C is produced in processing at the previous or earlier time in the object B.

In the partial processing shown in Fig. 26, in step 26\_1, referring to the output instruction tag table transferred to the object B in the form of arguments, the message number  $MA_A$  of the object A, which is associated with the method number  $ME_B$  succeeded to the object C, originally the message number of the object B, is obtained. In step 26\_2, a method element, in which the method number  $ME_B$  and the pointer to the object C are stored, is added to the method element list associated with the message number  $MA_A$  of the

message table of the object A.

In this manner, thereafter, it is possible to issue messages from the object A to the newly produced object C.

Fig. 27 is a flowchart useful for understanding another example of processings for an issue of a message of an object A, which is different from the example of that shown in Fig. 20.

In Fig. 27, steps 27\_1, 27\_3 and 27\_4 are the same as the steps 20\_1, 20\_3 and 20\_4 of Fig. 20, and the steps 5\_1, 5\_3 and 5\_4 of Fig. 5, respectively. Thus, the redundant explanation will be omitted.

In step 27\_2, the object B is called, where the method number  $ME_B$  and in addition the pointers P3, P4 and P5 are argument.

Upon receipt of the message, the object B executes a processing of a method specified by the method number  $ME_B$ .

Fig. 28 is a flowchart useful for understanding a seventh example of a partial processing of processings of an object B.

In step 28\_1, referring to the input data tag table transferred to the object B in the form of arguments, the pointer element list number  $IN_A$  of the object A is obtained from the data element list number  $OUT_B$  of the object B. In step 28\_2, the pointer element list (cf. Fig. 11 wherein the

pointer element list of the object B is shown) of the object A, which is associated with the obtained pointer element list number  $IN_A$ , is produced. In step 28\_3, the data element list (cf. Fig. 9 wherein the data element list of the object A is shown) of the object B, which is associated with the data element list number  $OUT_B$ , is produced. And in step 28\_4, a coupling processing of the data element list with the pointer element list (cf. Fig. 13 wherein the pointer of the object B indicates the data of the object A, and in this respect, positions of the object A and the object B are reversed, as compared with the present case) is executed.

In this manner, according to the present embodiment, a path for transfer of data between objects is formed during an execution of a processing, so called dynamically.

Fig. 29 is a flowchart useful for understanding a eighth example of a partial processing of processings of an object B.

With respect to the partial processing shown in Fig. 29, there is a need, prior to its execution, to perform the partial processing shown in Fig. 23 so that the object C is produced. However, with respect to timing of a producing of the object C, any times are acceptable if the object C is produced before the partial processing shown in Fig. 29.

In the partial processing shown in Fig. 29, in step

29\_1, referring to the input data tag table transferred to the object B in the form of arguments, the pointer element list number  $IN_A$  of the object A is obtained from the data element list number  $OUT_B$ , which is succeeded to the object C, originally the data element list number of the object B. In step 29\_2, the pointer element list of the object A, which is associated with the obtained pointer element list number  $IN_A$ , is produced. In step 29\_3, the data element list of the object C, which is associated with the data element list number  $OUT_B$ , is produced. And in step 29\_4, a coupling processing of the data element list of the object C with the pointer element list of the object A is executed.

In this manner, according to the present embodiment, a path for directly referring to data of the newly produced object C from the object A is formed during an execution of a processing, so called dynamically.

Fig. 30 is a flowchart useful for understanding a ninth example of a partial processing of processings of an object B.

In the partial processing shown in Fig. 30, in step 30\_1, referring to the output data tag table transferred to the object B in the form of arguments, the data element list number  $OUT_A$  of the object A is obtained from the pointer element list number  $IN_B$  of the object B. In step 30\_2, the

data element list of the object A, which is associated with the obtained data element list number  $OUT_A$  of the object A, is produced. In step 30\_3, the pointer element list of one's own (the object B), which is associated with the pointer element list number  $IN_B$ , is produced. And in step 30\_4, a coupling processing of the data element list of the object A with the pointer element list of the object B is executed.

In this manner, according to the present embodiment, a path for directly referring to data of the object A from the object B is formed during an execution of a processing, so called dynamically.

Fig. 31 is a flowchart useful for understanding a tenth example of a partial processing of processings of an object B.

With respect to the partial processing shown in Fig. 31, there is a need, prior to its execution, to perform the partial processing shown in Fig. 23 so that the object C is produced. However, with respect to timing of a producing of the object C, any times are acceptable if the object C is produced before the partial processing shown in Fig. 31.

In the partial processing shown in Fig. 31, in step 31\_1, referring to the output data tag table transferred to the object B in the form of arguments, the data element list number  $OUT_A$  of the object A is obtained from the pointer



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element list number  $IN_B$ , which is succeeded to the object C, originally the pointer element list number of the object B. In step 31\_2, the data element list of the object A, which is associated with the obtained data element list number  $OUT_A$  is produced. In step 31\_3, the pointer element list of the object C, which is associated with the pointer element list number  $IN_B$ , is produced. And in step 31\_4, a coupling processing of the data element list of the object A with the pointer element list of the object C is executed.

In this manner, according to the present embodiment, a path for directly referring to data of the object A from the object C is formed during an execution of a processing, so called dynamically.

While the above description concerns various types of partial processings during a processing of the object B, those various types of partial processings are not always executed independently, and if necessary, a plurality of partial processings are performed continuously or in their combination.

Fig. 32 is a flowchart useful for understanding processings of the input instruction tag table generating unit 24 of the object coupling unit 20 shown in Fig. 15.

An operator, who operates the computer system 100 (cf. Fig. 1) instructs the following items:

- (a) A pointer of the object A
- (b) A pointer of the object B
- (c) A method number  $ME_A$  of the object A
- (d) A message number  $MA_B$  of the object B

In the processing shown in Fig. 32, upon receipt of the above-noted instructions, a frame of the input instruction tag table having the same width as the maximum number  $MA_{BMAX}$  of messages of the object B is produced (step 32\_1). In step 32\_2, the method number  $ME_A$  of the object A is stored in the column of the message number  $MA_B$  of the object B of the frame thus produced. In step 32\_3, a pointer to the input instruction tag table is registered into the whole method elements (e.g. the method element shown in Fig. 19) related to the object B, of the object A. It is noted that Fig. 19 shows an illustration in which the pointer (P1) to the input instruction tag table has been already registered.

While the object B is typically dealt with according to the present embodiment, the output instruction bus portion of the object A produces input instruction tag tables related to all of the objects which have a possibility of receiving messages issued from the object A, and pointers to the input instruction tag tables are registered into method elements related to the objects associated with the input instruction

tag tables thus produced, respectively. This is the similar as to the matter of the output instruction tag tables, the input data tag tables and the output data tag tables.

Fig. 33 is a flowchart useful for understanding processings of the output instruction tag table generating unit 34 of the object coupling unit 30 shown in Fig. 16.

An operator, who operates the computer system 100 (cf. Fig. 1), instructs the following items in a similar fashion to that of wiring of LSI's:

- (a) A pointer of the object A
- (b) A pointer of the object B
- (c) A message number  $MA_A$  of the object A
- (d) A method number  $ME_B$  of the object B

In the processing shown in Fig. 33, upon receipt of the above-noted inputs, a frame of the output instruction tag table having the same width as the maximum number  $ME_{BMAX}$  of methods of the object B is produced (step 33\_1). In step 33\_2, the message number  $MA_A$  of the object A is stored in the column of the method number  $ME_B$  of the object B of the frame thus produced. In step 33\_3, a pointer to the output instruction tag table is registered into the whole method elements related to the object B, of the object A. It is noted that Fig. 19 shows an illustration in which the pointer (P2) to the output instruction tag table has been already

registered.

Fig. 34 is a flowchart useful for understanding processings of the input data tag table generating unit 44 of the object coupling unit 40 shown in Fig. 17.

An operator, who operates the computer system 100 (cf. Fig. 1), instructs the following items in a similar fashion to that of wiring of LSI's:

- (a) A pointer of the object A
- (b) A pointer of the object B
- (c) A pointer element list number  $IN_A$  of the object A
- (d) A data element list number  $OUT_B$  of the object B

In the processing shown in Fig. 34, upon receipt of the above-noted instructions, a frame of the input data tag table having the same width as the maximum number  $OUT_{BMAX}$  of data element lists of the object B is produced (step 34\_1). In step 34\_2, the pointer element list number  $IN_A$  of the object A is stored in the column of the data element list number  $OUT_B$  of the object B of the frame thus produced. In step 34\_3, a pointer to the input data tag table is registered into the whole method elements related to the object B, of the object A. It is noted that Fig. 19 shows an illustration in which the pointer (P3) to the input data tag table has been already registered.

Fig. 35 is a flowchart useful for understanding

processings of the output data tag table generating unit 54 of the object coupling unit 50 shown in Fig. 18.

An operator, who operates the computer system 100 (cf. Fig. 1), instructs the following items in a similar fashion to that of wiring of LSI's:

- (a) A pointer of the object A
- (b) A pointer of the object B
- (c) A data element list number of the object A
- (d) A pointer element list number of the object B

In the processing shown in Fig. 35, upon receipt of the above-noted inputs, a frame of the output data tag table having the same width as the maximum number  $IN_{BMAX}$  of pointer element lists of the object B is produced (step 35\_1). In step 35\_2, the data element list number  $OUT_B$  of the object A is stored in the column of the pointer element list number  $IN_B$  of the object B of the frame thus produced. In step 35\_3, a pointer to the output data tag table is registered into the whole method elements related to the object B, of the object A. It is noted that Fig. 19 shows an illustration in which the pointer (P4) to the output data tag table has been already registered.

While it is acceptable that the processings in Figs. 32 to 35 are executed independently and only one of four tag tables shown in Fig. 19 is registered into the method

element, it is also acceptable that two or more of these four tag tables are registered into one method element, if necessary or always. Further, although Figs. 32 to 35 fail to clearly state, in the event that anyone of the processings shown in Figs. 32 to 35 is executed, the pointer (P5) to the object A itself is registered into the method.

According to the embodiments explained referring to Figs. 15 to 35, not only are object-to-object coupled with one another in the initial state, but also a coupling of a message with a method, and a coupling of data with a pointer are performed during an execution of processings or dynamically. When a new object is produced, in a similar fashion as to the matter of the new object, the dynamic coupling is performed. In this manner, the new coupling is performed in accordance with conditions, and a very higher speed of transfer of messages and data among a plurality of objects is implemented.

Next, there will be described an embodiment concerning the interobject wiring editor unit 122 and the associated periphery. Here, of the embodiment concerning the interobject wiring editor unit 122 and the associated periphery, there will be described an embodiment of an object-between-network display method on the display screen 102a of the display unit 102 of the computer system 100.



implemented. This raises such a problem that users cannot readily grasp a relation between objects.

Further, according to the prior art system, the displayed object is of a hierarchical structure, and a device for displaying subnetworks constituting a certain object displays such subnetworks on a new screen or window. This raises such a problem that it is difficult for users to identify a connecting relation between a network of the parent object and the subnetworks, and in addition such a problem that the network of the parent object goes behind the new window.

Furthermore, according to the conventional object-between-network display, an object is fixed or variable in size. However, in the event that the object is fixed, in a case where the number of input and output terminals of the object is variable, there is a possibility that the selection of a large number of input and output terminals bring about narrow terminal intervals and thus it will be difficult to display terminal names. Also in the event that the object is variable in size, users have to control the size of the object. This raises such a problem that a work amount is increased.

Still further, according to the conventional object-between-network display, in the event that directions



of the flow of data and instructions in the network wiring are indicated, arrows are appended to only one terminal end or only both ends. Consequently, it is impossible to identify the flow direction in the middle of a wiring. Thus, in a case where the objects on both the ends of a wire are out of the display screen, there is a problem that it is impossible to identify whether the terminal of the object, which is a starting end or a terminal end, is an input terminal or an output terminal.

Still furthermore, according to the conventional object-between-network display, in the event that wires intersect, in order to identify whether two wires intersect or separate from one another, a mark such as a black point or the like is appended to a junction, alternatively a circular arc mark or the like is utilized. However, in the event that the mark such as a black point or the like is appended to a junction, it is necessary for users to understand a rule of the display. On the other hand, in the event that the circular arc mark is utilized, there is a problem that a radius of width is needed for a one wire.

In view of the foregoing problems involved in the object-between-network display, an embodiment, which will be described hereinafter, is to provide a display method easy for users to be understood.

Hereinafter, there will be described embodiments of an object-between-network display method according to the present invention. First, fundamental embodiments of an object-between-network display method according to the present invention will be explained, and then the more descriptive embodiments will be explained.

Fig. 36 is a typical illustration of a display screen useful for understanding an object-between-network display method according to an embodiment of the present invention. While Fig. 35 shows a lattice 201 which appears on the display screen 102a, it is noted that the lattice 201 is shown for the purpose of a clarification that the display screen 102a is partitioned into a plurality of display areas, and the lattice 201 is not displayed indeed on the display screen 102a.

The display screen 102a is partitioned by the lattice 201 into a plurality of display areas each consisting of one measure. Each of the display areas comprises an object display domain 203 for displaying one of a plurality of objects produced by an object-oriented programming, and a wiring display domain 204 for displaying a wiring to connect a plurality of objects to one another. The term "wiring" implies wires representative of the path 13a, 23a, 33a, 43a and 53a for a transfer of messages shown in Figs. 3 and 15 to



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FIG. 38(A)

constructed with subnetworks 1 and 2, respectively. Each of the subnetworks 1 and 2 comprises a plurality of objects and wirings for coupling the plurality of objects with one another. While Fig. 37 shows two stages of hierarchical structure, it is acceptable that three or more stages of hierarchical structure is provided.

Figs. 38(A) and (B) are illustrations each showing by way of example a display image consisting of a lot of objects and wirings. Fig. 38(A) shows a display image in its entirety, and Fig. 38(B) shows a partial image, with the object 205 as the central part.

Figs. 39(A) and (B) are illustrations each showing by way of example a display image of a subnetwork 206 constituting the object 205, instead of the object 205 shown in Figs. 38(A) and (B). Fig. 39(A) shows a display image in its entirety, and Fig. 39(B) shows a partial image, with the object 206 as the central part.

In the event that the subnetwork, which comprises the above-mentioned lower class of plurality of objects in hierarchical structure, instead of the object 205 included in a display image 207 shown in Figs. 38(A) and (B), and wiring for coupling those objects with one another, is displayed, a display area broader than a display area of the object 205 is allocated to the subnetwork 206; display areas, which are

arranged at the upper and lower sides of the display area of the subnetwork 206, are enlarged to right and left; display areas, which are arranged at the right and left sides of the display area of the subnetwork 206, are enlarged up and down; and as to display areas located at diagonal sides with respect to the display area of the subnetwork 206, the same size as that of the display areas on the display image shown in Figs. 38(A) and (B) in which the object 205 equivalent to the subnetwork 206 is displayed is allocated.

As shown in Fig. 39(B), there are displayed wires among a plurality of objects constituting the subnetwork 206, and in addition there are displayed wires among the subnetwork 206 and the surrounding networks of the subnetwork 206.

An adoption of the above-mentioned display method makes it possible to easily confirm the connecting state of the subnetwork with the surrounding networks, as compared with the conventional scheme in which the subnetwork 206 is displayed on an independent window.

Figs. 40(A) and (B) are illustrations each showing an alternative embodiment of the display method of the subnetwork. Fig. 40(A) shows an example of a display image before a subnetwork is displayed, the display image including an object equivalent to the subnetwork. Fig. 40(B) shows an

example of a display image in which the object is replaced by the subnetwork.

It is assumed that the object 205 included in the display image 207 shown in Fig. 40(A) is replaced by the subnetwork 206 equivalent to the object 205, as shown in Fig. 40(B).

The subnetwork 206 is allocated a display area broader than that of the object 205. However, the display areas located around the display image shown in Fig. 40(B) is display areas in which the same object is displayed, as compared with the display areas located around the display image shown in Fig. 40(A). Further, with respect to the position and the size of the sides adjacent to the periphery of the display image 207, of the display areas located around the display image, Fig. 40(A) and Fig. 40(B) are the same as each other. That is, in Fig. 40(A) and Fig. 40(B), the same information is displayed except for the point that the object 205 is replaced by the subnetwork 206, while Fig. 40(B) shows that the display area except for the subnetwork 206 is distorted. Thus, it is possible to prevent display areas located apart from the subnetwork 206 from disappearing from the display screen owing to displaying the subnetwork 206 as a substitute for the object 205 as in Fig. 39(A) compared with Fig. 37(A).

Accordingly, similar to the example of Figs. 39(A) and 39(B), an adoption of the above-mentioned display method makes it possible to easily confirm the connecting state of the subnetwork with the surrounding networks, and in addition makes it possible to confirm throughout the network displayed before a display of the subnetwork (the first image) in a state that the subnetwork is displayed, while deformed.

Figs. 41(A), (B) and (C) are illustrations each showing by way of example a display image having a display area in which a plurality of measures are coupled together. Fig. 41(A) shows the display image in its entirety, and Figs. 41(B) and (C) show partial images enlarged.

In the display image, there are shown various sizes of objects 210-215. The object 210 of these objects 210-215 is disposed in an display area partitioned with a measure of domain, and the remaining objects 211-215 each having another size are disposed in enlarged display areas in which a plurality of adjacent measures are coupled together to form a single display area. As shown in Figs. 41(B) and (C), the objects are standardized in their figure and size in accordance with the figure and size of the associated display areas, respectively.

An adoption of the above-mentioned display method makes it possible to display various sizes of objects with

sizes easy to see, and in addition possible to display a display screen easier to see through a standardization.

Next, there will be described a display method of wiring for connecting object-to-object with each other.

Fig. 42 is an illustration showing by way of example a display image characterized by a display method of wiring.

Displayed on a display screen 102a are objects 216 to 219. An output terminal 220 is connected to an input terminal 221 by a wire 222. An output terminal implies that data or instructions (messages) of the associated object are outputted to another object. An input terminal implies that data or instructions (messages) of another object are received thereat.

The wire 222 has information of a direction directed from the output terminal 220 to the input terminal 221, in which directions of data or instruction flows are repeatedly indicated for each short segment constituting the wire.

An adoption of the above-mentioned display method makes it possible to readily grasp directions of data or instruction flows even in the event that one or both of the objects to be connected together by the wire are located out of the display screen 102a.

Figs. 43(A) and (B) are illustrations each showing an alternative embodiment of the display method of the wiring.



A wire 223 comprises a central wire 223a and edge wires 223b along both ends of the central wire 223a. The central wire 223a and edge wires 223b are representative of mutually different display aspects, for example, hue, lightness and saturation.

In the event that the wire 223 comprising the central wire 223a and the edge wires 223b is adopted and such two wires 223 intersect, if those two wires are representative of mutually different data or control flows, as shown in Fig. 43(A), there is provided such a display that one of the two wires is divided into parts at the position that its central wire is in contact with the edge wires of the other wire or at the position that its central wire comes close to the edge wires of the other wire (according to the present embodiment, the former) so as to form a crossing with an overpass. On the other hand, if the two wires are representative of the same data or control flows, as shown in Fig. 43(B), there is provided such a display that the central wires 223a of both the wires are continued. An adoption of the above-mentioned display method makes it possible to readily determine as to whether the crossing wires are interconnected or simply cross each other.

The above is an explanation of the fundamental embodiment of the object-between-network display method

according to the present invention. Next, hereinafter, there will be described more specific embodiments of the object-between-network display method according to the present invention.

Figs. 44(A), (B) and (C) are illustrations useful for understanding a procedure for producing a display area for displaying a network of an object. In Fig. 44(A), the display screen is divided vertically and horizontally into four parts to form lattices. In Fig. 44(B), there is provided such an arrangement that for each measure of the produced lattices, a domain formed with length of 50 % of the measure in length and breadth is given for an area for disposing an object, and the domain is located at the center of the measure. In Fig. 44(B), the screen is divided on an equal basis, and the area for the object is located at the center of the measure. However, it is acceptable to designate a width of the measure, and as shown in Fig. 44(B), it is acceptable that the area for the object is located at the corner of the measure.

Fig. 45 is an illustration showing a state in which an object is disposed on a display screen by users. Figs. 46(A) and (B) are illustrations each showing a state in which a wiring among objects disposed on a display screen is performed by users.

As shown in Fig. 45, according to the present embodiment, when a user sets up an object 224, the object 224 set up by the user is automatically positioned at an area 225 specially designed for an object disposition, which is located closest to the set up position. Accordingly, it is possible to obtain an arrangement of objects in which objects are arranged in good order simply through users taking it easy to arrange objects. Further, according to the present embodiment, it is possible to automatically display wire 229 in an area 204 for displaying wirings of a network, as shown in Fig. 46(B), simply through users performing an operation of connecting terminals of object 226 and object 227 together with a straight line directly, as shown in Fig. 46(A). Consequently, it does not happen that the objects and the wirings overlap with each other. Thus, it is possible to display a network easy to see for users.

Figs. 47(A) and (B) are illustrations showing by way of example display screens of an object-between-network before and after display of the subnetwork, respectively. Fig. 48 is a flowchart useful for understanding a procedure for switching from the display of Fig. 47(A) to the display of Fig. 47(B).

At the stage that an image shown in Fig. 47(A) is displayed on a display screen, an object having a subnetwork

is designated through an operation of, for example, a mouse not illustrated or the like (step 48\_1), and it is instructed that the designated subnetwork is displayed (step 48\_2). In an image display apparatus, a measure whereat the selected object is located and lattices associated with the measure in vertical and horizontal directions are enlarged by the corresponding area necessary for a display of the subnetwork giving the corner of upper left of the measure as a starting point (step 48\_3). In step 48\_4, with the enlargement, a deformation of the objects arranged in vertical and horizontal directions and an extension of wirings are performed. In step 48\_5, a new lattice is formed within a measure enlarged for a display of the subnetwork and display the subnetwork on the lattice thus formed. In step 48\_6, the object of the subnetwork and the object of the neighboring network are connected together.

In this manner, a transfer of images from that shown in Fig. 47(A) to that shown in Fig. 47(B) is performed. Incidentally, according to the present embodiment, the starting point of the measure for an enlargement is given with the corner of upper left of the measure. However, it is acceptable that the enlargement starting point of the measure is given with another corner, or the center of the measure.

Figs. 50(A), (B) and (C) are explanatory views useful

for understanding a procedure of a subnetwork display. Fig. 49(A) shows an object-between-network before a display of a subnetwork, Fig. 49(B) shows a state in which the subnetwork is displayed with an enlargement and trapezoid of measures are formed on the upper and lower sides and the left and right sides of the enlarged measure, and Fig. 49(C) shows a state in which the subnetwork is displayed with an enlargement, and measures of the neighbor objects are deformed so that the whole network may be displayed within the screen.

Fig. 50 is a flowchart useful for understanding a procedure of the subnetwork display.

As shown in Fig. 50, an object having a subnetwork is selected through an operation of, for example, a mouse or the like (step 50\_1), and it is instructed that the selected subnetwork is displayed (step 50\_2). In an image display apparatus, a transfer of images from that shown in Fig. 49(A) to that shown in Fig. 49(C) is performed in accordance with the following procedure.

First, in step 50\_3, it is determined as to whether the subnetwork is accommodated within the display screen. If it is decided that the subnetwork is not accommodated within the display screen, a transfer of images from that shown in Fig. 49(A) to that shown in Fig. 49(B) is not performed. If

it is decided that the subnetwork is accommodated within the display screen, the process goes to step 50\_4 in which a measure whereat the selected object is located is enlarged by the corresponding area necessary for a display of the subnetwork giving the center of the measure as a starting point (cf. Fig. 49(A)).

In step 50\_5, as shown in Fig. 49(B), straight lines are drawn from corners of the enlarged measure to corners of the measures of the screen edges in vertical and horizontal directions to form trapezoids. In step 50\_6, each of the trapezoids is partitioned into necessary parts to produce trapezoid of measures. In step 50\_7, straight lines are drawn from corners of the measures of trapezoid to corners of the measures of the screen edges to produce residual measures. In step 50\_8, with a deformation of the measures, a deformation of the object and wirings are performed. Finally, in step 50\_9, the object of the subnetwork and the object of the neighboring network are connected together.

In this manner, a transfer of images from that shown in Fig. 49(A) to that shown in Fig. 49(C) is performed.

Incidentally, according to the present embodiment, the measures formed on the upper and lower sides and the left and right sides of the subnetwork are given with a figure of trapezoid. However, it is acceptable that such measures are

given with a figure of curve.

Figs. 51(A), (B) and (C) are typical illustrations each showing an embodiment in which a display area representative of an object is formed with a single measure or a plurality of measures coupled with one another. According to the present embodiments, a number of measures to be used is altered in accordance with a number of terminals of an object. Fig. 51(A) shows a case where one measure is used by one and an object has the maximum 12 terminals. Fig. 50(B) shows a case where two measures are used by two and an object has the maximum 30 terminals. Fig. 51(C) shows a case where four measures are used by four and an object has the maximum 48 terminals. As a number of terminals of the object is increased, a number of measures may be increased.

Figs. 52(A) and (B) are illustrations useful for understanding by way of example a display method of wiring. In Fig. 52(A), a screen 1 shows a state of halfway in which a wiring from an output terminal of an object 1 (obj 1) to an input terminal of an object 2 (obj 2) is conducted. While the object 1 disappears from the screen 1, it will be understood from a figure of the line drawn out that a terminal to be connected is an input terminal. Likewise, with respect to a screen 2, in the event that a wiring from an input terminal of an object 4 (obj 4) to an output

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terminal of an object 3 (obj 3) is conducted, even if the object 4 disappears from the screen 2, it will be understood from a figure of the line that a terminal to be connected is an output terminal. Fig. 52(B) shows a network after a completion of wiring in which wires have been changed to the usual solid lines. According to the present embodiment, while the wires are changed to the usual solid lines at the time when all of the wirings have been completed, it is acceptable that a wire is changed to the usual solid line whenever one wiring is completed.

Fig. 53 is a typical illustration showing by way of example a display of wiring. Fig. 54 is a flowchart useful for understanding a procedure of executing the wiring shown in Fig. 53.

According to the present embodiment, there is adopted a wiring consisting of the central wires and the edge wires, as described referring to Figs. 43(A) and (B), and when a user selects the output terminal and input terminal which are connected together, an automatic wiring is conducted in accordance with a procedure shown in Fig. 54.

In step 54\_1, a user selects the output terminal and input terminal which are connected together. In step 54\_2, a vertical lane A is produced at the output terminal end. In step 54\_3, overwritten with a line is a horizontal lane of



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the output terminal from the output terminal to the vertical lane A, so that a wiring on the overwritten portion is displayed on the display screen. In step 54\_4, it is determined whether the input terminal is over against the output terminal. What is meant by that the input terminal is over against the output terminal is that for example, as in the relation between an output terminal 1 and an input terminal q, the output terminal and the input terminal are located so as to be opposite to each other. On the other hand, in case of the relation between an output terminal 7 and an input terminal r, it is determined that they are not over against each other.

In a case where it is determined that the input terminal is over against the output terminal, the process goes to step 54\_5 in which the vertical lane A is overwritten with a line up to the horizontal lane of the input terminal. If there is already a portion connected with the horizontal lane, for example, as in a case where a wiring between an output terminal 8 and an input terminal c is already conducted, and in addition a wiring between the output terminal 8 and an input terminal e is newly conducted, a coupling process as shown in Fig. 43(B) is performed. In step 54\_6, the horizontal lane of the input terminal is overwritten with a line up to the input terminal.

In a case where in step 54\_4, it is determined that the input terminal is not over against the output terminal, the process goes to step 54\_7 in which the vertical lane is produced at the input terminal end. In step 54\_8, a horizontal lane C not sandwiched in objects is produced. In step 54\_9, the vertical lane A is overwritten with a line up to the horizontal lane C. If there is already a portion connected with the horizontal lane, a coupling process is performed.

In step 54\_10, the horizontal lane C is overwritten with a line up to the vertical lane B. In step 54\_11, the vertical lane B is overwritten with a line up to the horizontal lane of the input terminal. If there is already a portion connected with the horizontal lane, a coupling process is performed.

Thereafter, the process goes to step 54\_6 in which the horizontal lane of the input terminal is overwritten with a line up to the input terminal.

Each of Figs. 55-57 are a flowchart useful for understanding an alternative embodiment of a procedure of executing the wiring. Figs. 58-62 are typical illustrations each showing a result obtained from an execution of wiring according to the wiring procedures shown in Figs. 55-57. Figs. 63(A), (B) and (C) are typical illustrations each

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showing a result obtained from an execution of wiring according to the wiring procedures shown in Figs. 55-57. An adoption of the wiring procedures according to the present embodiment makes it possible to perform an automatic wiring, even if there exist objects which are not uniform in figure, different from the case in which the wiring procedure shown in Fig. 54 is adopted.

As shown in Fig. 55, in step 55\_1, a user selects the output terminal and input terminal which are connected together. In step 55\_2, a lane 1 (cf. Figs. 58-62) perpendicular to the output terminal is provided in an wiring area having the output terminal. In step 55\_3, a line is drawn on a lane 2 (cf. Figs. 58-61) of the output terminal from the output terminal to the lane 1. In step 55\_4, it is determined whether the input terminal is over against the output terminal. In a case where the input terminal is over against the output terminal, as shown in Fig. 58 of Figs. 58-61, the process goes to step 55\_5 in which a line is drawn from a node a of the lane 1 and lane 2 to a lane 3 of the input terminal. In step 55\_6, a line is drawn from a node b, which is a cross point of the lane 1 and lane 3, to the input terminal. Thus, the wiring is completed, in the event that the input terminal is over against the output terminal, as shown in Fig. 58.



in which the area of the object having the input terminal (including not only the disposing area of the object itself, but also the neighbor wiring areas, for example, in case of Fig. 58, the area of the object having the input terminal implies all of the partial areas p, q, r, s, u, v, w and x) is extended vertically and horizontally. In step 56\_2, when it is determined that the line does not reach the area of the object having the input terminal (for example, in case of Fig. 58, all of the partial areas p, q, r, s, u, v, w and x), the process goes to step 56\_12 in which as shown in Fig. 63(C), a lane C perpendicular to the line is provided on a wiring area of a position whereat the tip of the line is located now, and the lane C thus provided is connected to the line. In step 56\_13, a line is drawn along the lane C from the node k toward the object having the input terminal.

In a case where in step 56\_3, when it is determined that the line does not reach the wiring area of the input terminal (for example, in case of Fig. 58, the partial areas p, s and v), the process goes to step 57\_1. This case will be described latter.

In step 56\_4, it is determined as to whether the line reaches a position perpendicular to the lane 3 of the input terminal, and when it is decided that the line is perpendicular to the lane 3, the process goes to step 56\_5 in

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which as shown in Fig. 59, the line is extended to the lane 3. In step 56\_6, the line is drawn on the lane 3 from the node C crossing to the lane 3 to the input terminal. Thus, the wiring shown in Fig. 59, for example, is completed.

On the other hand, in step 56\_4, when it is decided that the line is not perpendicular to the lane 3 of the input terminal, the process goes to step 56\_7 in which as shown in Fig. 60, a lane 4 perpendicular to the line is provided on the wiring area of the input terminal. In step 56\_8, the line is drawn from a node d to the lane 3. In step 56\_9, the line is drawn from a node e to the input terminal. Thus, the wiring shown in Fig. 60, for example, is completed.

In step 56\_3, when it is determined that the line does not reach the wiring area of the input terminal, the process goes to step 57\_1 of Fig. 57 in which it is determined as to whether the line reaches a position perpendicular to the lane 3 of the input terminal. When it is decided that the line is perpendicular to the lane 3, the process goes to step 57\_2 in which as shown in Fig. 61, a lane 5 is provided on the present wiring area. In step 57\_3, a lane 6 is provided on the wiring area of the input terminal. In step 57\_4, the line is drawn from a node f along the lane 5 to the lane 6. In step 57\_5, the line is drawn from a node g to the lane 3. In step 57\_6, the line is

drawn from a node h to the input terminal. Thus, the wiring shown in Fig. 61, for example, is completed.

In step 57\_1, when it is decided that the line is not perpendicular to the lane 3 of the input terminal, the process goes to step 57\_7 in which as shown in Fig. 62, a lane 7 perpendicular to the line is provided on the wiring area of the input terminal. In step 57\_8, the line is extended from the node a to a lane 7. In step 57\_9, the line is drawn from a node i to the lane 3. In step 57\_10, a lane perpendicular to the line is provided on the present wiring area, and the lane thus provided is connected to the line. In step 57\_11, the line is drawn from a node j to the input terminal. Thus, the wiring shown in Fig. 62, for example, is completed.

Practicing the wiring procedures shown in Figs. 55-57 makes it possible to complete the wirings in case of a disposing state of each of the objects of Figs. 63(A) to (D) as well.

As described above, according to the object-oriented programming apparatus and an object-oriented program storage medium of the present invention, there is implemented a higher speed of transfer of information among a plurality of objects in an object-oriented programming. Thus, it is possible to realize a software system wherein a lot of small

objects are gathered, without decreasing a processing speed, thereby dramatically improving reuse of the objects.

Further, according to the case where the object-oriented programming apparatus of the present invention is provided with an object display unit, and the object-between-network display method according to the present invention, it is possible to display an object-between-network easy to be understood thereby contributing to an improvement of a working efficiency for users.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by those embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

As described above, according to the object-between-network display method according to the embodiment of the present invention, it is possible to display an object-between-network easy to be understood thereby contributing to an improvement of a working efficiency for users.

The above is an explanation concerning an embodiment of an object-between-network display method on the display





objects (this is referred to as "child object"), there is a need to prepare a large number of terminals for a relay use for the purpose of connection of objects, when objects to be connected are mutually far hierarchies. Thus, it takes a lot of procedure for a wiring, and thus it is troublesome.

On the other hand, in the event that objects are of a hierarchical structure, and in case of a scheme wherein it is permitted to directly connect objects, which belong mutually different hierarchies, with one another, there will be provided a wiring diagram which does not take into account of a hierarchy. Thus, this raises such a problem that the wiring diagram is not so easy to see and it is difficult to grasp the wiring structure in its entirety.

Further, when there is a need to replace the object once wired by another object, in order to implement the replacement, there is a need to remove the wiring of the previous object and do over again the wiring for the new object. Thus, it takes a lot of procedure for the replacement.

This is a similar as to the matter of that the object once wired on a certain hierarchy is shifted to another hierarchy, for example, a one stage lower-order hierarchy. Also in this case, it takes a lot of procedure such that the wiring of the object before a shift is removed, a parent object is placed wired thereat, the removed object is placed

as a child object of the parent object, and a wiring between the parent object and the child object is conducted.

Further, according to the conventional scheme, there has been associated with such a problem that as the interobject wiring is complicated, a connecting relation among objects is hardly to be understood from an indication of the wiring diagram. Especially, in the event that a bus representative of a flow of request for processing, which bus referred to as a "instruction bus", is connected to a plurality of objects on a branching basis, it is difficult to grasp a running sequence of the processing among the plurality of objects from the indication of the wiring diagram. Accordingly, it is also difficult to alter the running sequence on the wiring diagram.

In view of problems involved in the above-mentioned interobject wiring, the embodiment, which will be described hereinafter, relates to a scheme of facilitating a wiring work.

Fig. 64 is a schematic diagram showing a basic structure of an object-oriented programming supporting apparatus and a program storage medium for use in an object-oriented programming according to an embodiment of the present invention.

## An object-oriented programming supporting apparatus

300 supports an object-oriented programming for coupling a plurality of objects each having data and operation with each other in accordance with an instruction. The object-oriented programming supporting apparatus 300 comprises a display means 301, an object coupling means 302, a hierarchical structure construction means 303 and a handler 304.

The display means 301 displays objects each represented by a block representative of a main frame of an object, a data output terminal for transferring data of the object to another object, a data input terminal for receiving data from another object, a message terminal for issuing a message to make a request for processing to another object, and a method terminal for receiving a processing request from another object to execute a method, the object being represented by a hierarchical structure which permits one or a plurality of objects to exist in a single object, and in addition displays a wiring for coupling terminals of a plurality of objects. On the computer system 100 shown in Fig. 1, the display means 301 is constituted of the image display unit 102, a software for displaying the above-mentioned objects and wirings on the display screen 102a of the image display unit 102, and a CPU for executing the software.



object coupling means, and likewise the software itself for implementing the hierarchical structure construction means 303 is also referred to as the hierarchical structure construction means. A program, in which the object coupling means 302 and the hierarchical structure construction means 303 are combined in the form of software, corresponds to the object-oriented programming program referred to in the present invention. The recording medium 310, in which the object-oriented programming program is stored, corresponds to the program storage medium for use in an object-oriented programming referred to in the present invention. In the computer system 100 shown in Fig. 1, the storage unit 105, in which the object-oriented programming program has been stored, corresponds to the program storage medium for use in an object-oriented programming referred to in the present invention. When the object-oriented programming program is stored in the MO 110, the MO 110 also corresponds to the program storage medium for use in an object-oriented programming referred to in the present invention.

Fig. 65 is a conceptual view showing exemplarily an involving relation among objects. Fig. 66 is a typical illustration showing a connecting relation among objects for defining a hierarchical structure.

As shown in Fig. 65, the whole is considered as one

object, and this is referred to as an object A. The object A includes three objects, that is, an object B, an object C and an object D. The object C includes an object E, an object F and an object G. The object F includes an object H.

If this is expressed with a hierarchical structure, the expression is given as shown in Fig. 66. The hierarchical structure of objects expressed in this manner is referred to as an "object tree".

In Fig. 66, the objects arranged in a horizontal direction implies that they are disposed in the same-order hierarchy. With respect to the objects connected with each other in a vertical direction, the object disposed at higher-order hierarchy implies a parent object, and the object disposed at lower-order hierarchy implies a child object of the parent object.

Fig. 67 is a typical illustration showing a pointer for determining a connecting relation of a certain object to another object.

Each of the objects has, as pointers for defining a parent-child relationship, "pointers to higher/lower-order hierarchy" comprising a "pointer to higher-order hierarchy" and a "pointer to lower-order hierarchy", and as pointers for connecting objects arranged in the same-order hierarchy, "pointers to same-order hierarchy" comprising two pointers of

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a "FROM" and a "TO". Further, each of the objects has, pointers for use in wiring representative of a flow of data and instructions among objects, "pointers to buses" comprising two pointers of an "IN" and an "OUT", and "pointers to cables" comprising four pointers of an "instruction", a "data", a "tag instruction" and a "tag data".

The "pointer to higher-order hierarchy" and the "pointer to lower-order hierarchy", which constitute the "pointers to higher/lower-order hierarchy", are, for example, in case of the object A shown in Fig. 66, the pointer to the wiring editor and the pointer to the object B, respectively.

The two pointers of the "FROM" and the "TO", which constitute the "pointers to same-order hierarchy", are, for example, in case of the object C shown in Fig. 66, the pointer to the object B and the pointer to the object D, respectively.

In this manner, there is constructed a hierarchical structure, for example, as shown in Fig. 66, comprising the "pointer to lower-order hierarchy" and the "pointers to same-order hierarchy".

Fig. 68 is a typical illustration showing one of the bus elements constituting the bus element list to be connected to the "pointers to buses" shown in Fig. 67. Fig. 69 is a typical illustration showing one of the cable



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elements constituting the cable element list to be connected to the "pointers to cables" shown in Fig. 67. Fig. 70 is a typical illustration showing exemplarily a wiring among objects.

Each of the bus elements arranged on the bus element list defines a bus (terminal) to be connected to another object. Each of the cable elements arranged on the cable element list defines a coupling relation (wiring) between terminals of child object-to-child object when the associated object is given as a parent object.

Fig. 67 shows two pointers "IN" and "OUT" as pointers constituting pointers to the bus. Connected to the pointer "IN" is the bus element list defining a bus which feeds data or messages to the object shown in Fig. 67. Connected to the pointer "OUT" is the bus element list defining a bus which outputs data or messages from the object shown in Fig. 67 toward other object.

In Fig. 67, connected to the pointer "IN" is the bus element list comprising two bus elements BUS 1 and BUS 2. Specifically, the bus element BUS 1 is connected to the pointer "IN", and the bus element BUS 2 is connected to the bus element BUS 1. Connected to the pointer "OUT" is the bus element list comprising two bus elements BUS 3 and BUS 4. Specifically, the bus element BUS 3 is connected to the

pointer "OUT", and the bus element BUS 4 is connected to the bus element BUS 3.

As shown in Fig. 68, each of the bus elements comprises a "pointer to substantial object", "pointer to bus of substantial object", "pointer to next bus element (BUS)" and "other data". It is noted that a terminal of an object is referred to as a "bus".

In the arrangement shown in Fig. 70, in the event that the object shown in Fig. 67 is object A shown in Fig. 70, the bus element BUS 1 corresponds to, for example, "BUS 1" of the object A shown in Fig. 70, and the "pointer to substantial object" corresponds to a pointer to an object (here object B) connected to BUS 1 of object A, of object B and object C included in object A shown in Fig. 70. The "pointer to bus of substantial object" of the bus element BUS 1 corresponds to a pointer to a bus (in case of Fig. 70, BUS 1 of object B) of object B as the substantial object, which bus is connected to "BUS 1" of the object A. The "pointer to next bus element (BUS)" constituting the bus element BUS 1 corresponds, in case of the bus element BUS 1 in Fig. 67, to a pointer to the bus element BUS 2. The "other data" constituting the bus element BUS 1 includes a distinction as to whether the bus (in this case, "BUS 1" of the object A shown in Fig. 70) associated with the bus element is a bus for transfer of data

or a bus for transfer of a message (or instruction).

Incidentally, as to an identification between a bus (IN) at the end of receiving data or instruction and a bus (OUT) at the end of transmitting data or instruction, as shown in Fig. 67, it is implemented by separating the "pointers to buses" into "IN" and "OUT".

In Fig. 67, "pointers to cables" comprises four pointers, that is, "instruction", "data", "tag instruction", and "tag data", to each of which a cable element list is connected. Fig. 67 exemplarily shows only a cable element list connected to the "data". Connected to the "data" is directly a cable element CABLE 1. Connected to the cable element CABLE 1 is a cable element CABLE 2. And connected to the cable element CABLE 2 is a cable element CABLE 3.

The "pointers to cables" is used for management of a connecting state (wiring) of buses of child object-to-child object by a parent object. In the example shown in Fig. 70, the wiring of buses between the object B and the object C is managed. Incidentally, the wiring between the object A as a parent object and the object B as a child object, or the wiring between the parent object A and the object C as a child object is managed, as mentioned above, by the bus element list connected to the "pointers to buses".

The four pointers, that is, "instruction", "data",

"tag instruction", and "tag data", which constitute the "pointers to cables", manage a wiring indicative of a flow of messages (instruction), a wiring indicative of a flow of data, a wiring indicative of a flow of an instruction, which is formed dynamically during an execution, as mentioned above, and a wiring indicative of a flow of data, which is formed dynamically during an execution, respectively.

As shown in Fig. 69, a cable element "CABLE" is associated with two terminal elements "TERMINAL". The cable element "CABLE" comprises a pointer to the first terminal element of the two terminal elements "TERMINAL", and a pointer to the next cable element. The terminal element "TERMINAL" comprises a "pointer to an object", a "pointer to a bus of the object", and a "pointer to the next terminal pointer".

Fig. 69 shows exemplarily a cable element for managing a wiring for connecting the bus 2 of the object B with the bus 1 of the object C, shown in Fig. 70, in which the first terminal element stores therein a pointer to an object B and a pointer to a bus 2 of the object B, and the second terminal element stores therein a pointer to an object C and a pointer to a bus 1 of the object C. In this manner, the bus 2 of the object B and the bus 1 of the object C are coupled with each other through the wiring. It is

noted that the first terminal element of the two terminal elements is associated with the bus of the output end of data or instruction, and the second terminal element is associated with the bus of the input end of data or instruction.

The cable element shown in Fig. 69 is managed, as mentioned above, by the object A which is a common parent object for both the objects B and C.

The above are the general explanations of a management of pointers for determining a hierarchical structure of objects, a management of pointers for determining buses of objects, and a management of pointers for determining a wiring for connecting buses of objects. Next, there will be explained more specific embodiments of the object-oriented programming supporting apparatuses according to the present invention, and programs for an object-oriented programming, which are stored in a program storage mediums for use in an object-oriented programming according to the present invention.

According to the first object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention, and programs for an object-oriented programming, which are stored in the first program storage medium for use in an object-oriented programming, of the program storage mediums

for use in an object-oriented programming according to the present invention, the hierarchical structure construction means 303 shown in Fig. 64 has means for producing a duplicate object of a substantial object designated in accordance with an instruction from the handler 304, and for disposing the duplicate object at a hierarchy different from a hierarchy at which the substantial object is disposed, and the object coupling means 302 receives from the handler 304 an instruction as to a wiring between the duplicate object and another object in the wiring of the hierarchical structure in which the duplicate object is disposed, and constructs a coupling structure in which the duplicate object and the associated substantial object are provided in the form of a united object.

Fig. 71 is a conceptual view of a duplicate object. Fig. 72 is a typical illustration showing a hierarchical structure (object tree) of the objects shown in Fig. 71.

An object A is connected to an wiring editor. Connected to the object A is an object B in a lower-order hierarchy. Connected to the object B is an object C in the same-order hierarchy. Connected to the object C is an object D in a lower-order hierarchy. Connected to the object D is an object E in the same-order hierarchy.

In the event that the objects B and E, which are

disposed at mutually different hierarchy, are connected with each other through a wiring, it is acceptable that a bus (terminal) is formed on the object C which is a parent object of the object E, and the terminal of the object C is connected to the bus of the object E, and in addition the terminal of the object C is connected to the terminal of the object B. However, this work takes a trouble for wiring. In order to avoid such a trouble, according to the present embodiment, a duplicate object E' of which the substantial object is the object E is disposed at the hierarchy at which the objects B and D are disposed, and the bus of the duplicate object E' is connected to the bus of the object B through a wiring on the hierarchy at which the object B and the duplicate object E' are disposed.

Fig. 73 is a flowchart useful for understanding a building process for the duplicate object.

First, in step 73\_1, with respect to the designated object (e.g. object E), a duplicate object E' is built through copying the object E. Here a wiring among objects is aimed. Thus, there is no need to copy even the substance of the program constituting the object E and only information necessary for a display and a wiring of objects is copied. In this meaning, the "copy" referred to as the present invention means a copy of information necessary for a display

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2. a pointer to the substantial object E and a pointer to the bus associated with the substantial object E, are written.

Copied on the duplicate object E' are the bus elements BUS 1, BUS 2, ... arranged in the "pointers to buses" of the substantial object E in the form of an arrangement as it is. Each of the bus elements BUS 1', BUS 2', ... of the duplicate object E' copied stores a pointer to the substantial object E and a pointer to the associated bus, of the substantial object E (cf. Fig. 68). After the duplicate object is built in this manner, when a wiring between the object B and the duplicate object E' is instructed, as shown in Fig. 71, the associated cable element and two terminal elements are arranged on the "pointers to cables" of the object A which is a parent object of the object B and the duplicate object E' (cf. Fig. 69).



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After a wiring work, and when wiring data for interpreter use, which is stored in the wiring data for interpreter use shown in Fig. 2, is generated, the associated bus element of the substantial object E is found from the bus element list of the duplicate object E' to construct an interobject coupling structure in which the duplicate object E' and the substantial object E are formed in a united body as one object.

Next, there will be explained embodiments of the second object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention, and programs for an object-oriented programming, which are stored in the second program storage medium for use in an object-oriented programming, of the program storage mediums for use in an object-oriented programming according to the present invention.

According to the second object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention, and programs for an object-oriented programming, which are stored in the second program storage medium for use in an object-oriented programming, of the program storage mediums for use in an object-oriented programming according to the

present invention, the object coupling means 302 shown in Fig. 64 releases a coupling structure of the object before a replacement with another object in accordance with an instruction from the handler 304, and causes the object after the replacement to succeed to the coupling structure of the object before the replacement with another object, and the hierarchical structure construction means 303 disposes the object after the replacement, instead of the object before the replacement, at a hierarchy at which the object before the replacement is disposed.

Fig. 75 is a conceptual view showing a coupling relation of objects before a replacement of objects. Fig. 76 is a typical illustration showing an object tree concerning the objects shown in Fig. 75.

An object A is connected to an wiring editor. Connected to the object A is an object B in a lower-order hierarchy. Connected to the object B is an object C in the same-order hierarchy. Connected to the object C is an object D in the same-order hierarchy. There exists an object E which is not incorporated into the hierarchical structure. The object C is replaced by the object E.

Fig. 77 is a conceptual view showing a coupling relation of objects after a replacement of objects. Fig. 78 is a typical illustration showing a part of the object tree



drop is the object C, the object tree is altered from the state shown in Fig. 76 to the state shown in Fig. 78.

This change is implemented in which a manner that, of the pointers of the objects shown in Fig. 76, the pointer to the object E is written, instead of the pointer to the object C, into "T0" of the object B; the pointer to the object B and the object E are written into "FROM" and "T0" of the object E, respectively; and the pointer to the object E is written, instead of the pointer to the object C, into "FROM" of the object D.

Next, the wiring of the object C concerned in drop is retrieved from the cable element list of the object A which is a parent of the object C concerned in drop (step 79\_6).

Fig. 80 is a typical illustration showing a part of the cable element list connected to an object A.

It is recorded in this part that the bus 3 of the object C and the bus 4 of the object D are connected to the terminals indicated by the cable element CABLE a. In this manner, the cable elements are sequentially retrieved to identify the wiring connected to the object concerned in drop.

When the wiring connected to the object concerned in drop is identified, as shown in Fig. 80, the wiring is released and connected to the associated bus of the object E after replacement (step 79\_7). When the associated bus of

the object E after replacement does not exist and the wire cannot be altered, it is displayed on the display screen 102a and the wiring is cancelled.

Next, there will be explained embodiments of the third object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention, and programs for an object-oriented programming, which are stored in the third program storage medium for use in an object-oriented programming, of the program storage mediums for use in an object-oriented programming according to the present invention.

According to the third object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention, and programs for an object-oriented programming, which are stored in the third program storage medium for use in an object-oriented programming, of the program storage mediums for use in an object-oriented programming according to the present invention, the hierarchical structure construction means 303 is in response to an instruction from the handler 304 such that a plurality of objects from among the objects disposed at a predetermined hierarchy are designated and the plurality of objects are rearranged on the lower-order hierarchy by one stage, and rearranges the plurality of

objects on the lower-order hierarchy by one stage, and produces and arranges an object including the plurality of objects on the predetermined hierarchy in such a manner that a coupling structure among the plurality of objects and a coupling structure among the plurality of objects and objects other than the plurality of objects are maintained.

Fig. 81 is a conceptual view showing a coupling relation among objects before a movement of objects. Fig. 82 is a typical illustration showing an object tree concerning the objects shown in Fig. 81.

As shown in Fig. 82, an object A is connected to an wiring editor. Connected to the object A is an object B in a lower-order hierarchy. Connected to the object B is an object C in the same-order hierarchy. Connected to the object C is an object D in the same-order hierarchy. Connected to the object D is an object E in the same-order hierarchy.

It is assumed that the interobject network as shown in Fig. 81 is displayed on the display screen 102a, and the mouse 104 is operated to select the object C and the object D as the objects to be moved to the lower-order hierarchy by one stage.

Fig. 83 is a conceptual view showing a coupling relation of objects after a movement of objects. Fig. 84 is

a typical illustration showing an object tree concerning the objects shown in Fig. 83.

An object F is built on the same hierarchy as that of an object B. An object C and an object E are arranged on a lower-order hierarchy of the object F in the form of children objects of which a parent is the object F.

Before a movement, as shown in Fig. 81, the bus 3 of the object B is directly connected to the bus 1 of the object C. After a movement, however, as shown in Fig. 83, the bus 3 of the object B is connected to the bus 1 of the object F, and the bus 1 of the object F is connected to the bus 1 of the object C. And with respect to a connection of the object D with the object E, the bus 3 of the object D is connected to the bus 2 of the object F, and the bus 2 of the object F is connected to the bus 1 of the object E.

Fig. 85 is a flowchart useful for understanding a processing for a movement of objects and a change of wiring of objects.

When the object, which is to be moved to a lower-order hierarchy by one stage, is selected, it is identified as to what objects (here, objects C and D shown in Fig. 82) have been selected (step 85\_1). And a new object (here, object F) is built on the same hierarchy as the selected objects (step 85\_2). In step 85\_3, the selected

objects (here, objects C and D) are replaced by the new object (object F).

Fig. 86 is a typical illustration showing a state of an alteration of an object tree.

In step 85\_2, when the object F is built, the connection between the object B and the object C is cancelled, and the object B is connected to the object F in the same-order hierarchy. And the connection between the object D and the object E is cancelled, and the object F is connected to the object E in the same hierarchy. And the object C is connected to the object F in the lower-order hierarchy. In this manner, the object tree after an object movement, as shown in Fig. 84, is completed.

Incidentally, it is noted that the alternation of the pointer for the alternation of the object tree can be performed in a similar fashion to that of the explanation made referring to Fig. 78, and thus the redundant explanation will be omitted.

Next, as shown in step 85\_4 of Fig. 85, the wiring connected to the selected objects (objects B and C) is retrieved from the cable element list connected to the parent object (object A) of the selected objects (objects B and C).

Fig. 87 is a typical illustration showing a part of the cable element list connected to the object A.



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In Fig. 87, there are shown that the wiring of the bus 4 of the object C and the bus 1 of the object D are made on the cable element CABLEa, and that the wiring of the bus 3 of the object D and the bus 1 of the object E are made on the cable element CABLEb. Here, it is noted that the wiring of the bus 4 of the object C and the bus 1 of the object D shown on the cable element CABLEa is typically representative of the wiring between the objects (objects B and C) selected to be moved to the lower-order hierarchy by one stage, as shown in Fig. 81, and the wiring of the bus 3 of the object D and the bus 1 of the object E shown on the cable element CABLEb is typically representative of the wiring between the object (object D) to be moved to the lower-order hierarchy by one stage and the object (objects E) not to be moved and to stay at the same-order hierarchy.

In the step 85\_4 of Fig. 85, when the retrieval of the cable element list is carried out as mentioned above, the process goes to step 85\_5 in which it is determined whether the wiring connected to the selected objects (here objects B and C) located through the retrieval is the wiring between the objects (objects B and C) inside of the new object (object F), or the wiring between the internal object and the external object with respect to the the new object (object F). In this determination, when it is determined

that the wiring of interest is the wiring (corresponding to the wiring of the cable element CABLEa shown in Fig. 87) between the objects inside of the new object (object F), the process goes to step 85\_6 in which the wiring is moved from the parent object (object A) to the new object (object F).

Fig. 88 is an explanatory view useful for understanding a movement of wiring to a new object.

The cable element CABLEa is removed from among the cable element list connected to the object A, and is incorporated into the cable element list connected to the object F.

In the step 85\_5 of Fig. 85, when it is determined that the wiring of interest is the wiring (corresponding to the wiring of the cable element CABLEb shown in Fig. 87) between the internal object and the external object with respect to the the new object (object F), the process goes to step 85\_7 in which a wiring bus is produced on the new object (object F).

Fig. 89 is a typical illustration of a bus for use in wiring, the bus being built on an object F.

In Fig. 89, a bus element BUS 2 is connected to "OUT" (cf. Fig. 67) of the object F. The bus element BUS 2 corresponds to the bus 2 of the object F shown in Fig. 83, and has a pointer to the object D and a pointer to the bus 3

of the object D. That is, the bus element BUS 2 forms, as shown in Fig. 83, a wiring between the bus 2 of the object F and the bus 3 of the object D. It is to be noted that the bus element BUS 2 shown in Fig. 89 is exemplarily shown, and in case of the wiring shown in Fig. 83, a connecting bus element is disposed also in "IN" of the object F so that a wiring between the bus 1 of the object F and the bus 1 of the object C is implemented.

In step 85\_8 of Fig. 85, a wiring connected to the object inside a new object (object F) is changed in connection to the new object (object F).

Fig. 90 is a typical illustration showing a state of a change of an object in wiring from an object (object D) inside a new object (object F) to the object F.

The cable element CABLEb of the object A shown in Fig. 87 is indicative of a wiring between the bus 3 of the object D inside the object F and a wiring between the bus 1 of the object E outside the object F. As shown in Fig. 90, the bus 3 of the object D is changed to the bus 2 of the object F thereby forming a wiring between the bus 2 of the object F and the bus 1 of the object E.

Incidentally, the step 85\_4 in Fig. 85 is repeatedly performed by a necessary number of times.

Next, there will be explained embodiments of the

fourth object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention, and programs for an object-oriented programming, which are stored in the fourth program storage medium for use in an object-oriented programming, of the program storage mediums for use in an object-oriented programming according to the present invention.

According to the fourth object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention, the display means 301 shown in Fig. 64 has, in case of existence of a plurality of method terminals (messages or instructions) connected to one message terminal (a bus for outputting a message or an instruction) designated in accordance with an instruction through the handler 304, means for displaying a list indicative of an execution sequence of a plurality of methods associated with the plurality of method terminals, and the object coupling means 302 has means for reconstructing a coupling structure in which the execution sequence of the plurality of methods appearing at the list displayed on the display means 301 are altered.

Further, according to programs for an object-oriented programming, which are stored in the fourth program storage

medium for use in an object-oriented programming, of the program storage mediums for use in an object-oriented programming according to the present invention, the object coupling means 302 has, in case of existence of a plurality of method terminals connected to a designated one message terminal, means for making up a list indicative of an execution sequence of a plurality of methods associated with the plurality of method terminals, and means for reconstructing a coupling structure in which the execution sequence of the plurality of methods are altered in accordance with an alteration instruction of the execution sequence of the plurality of methods appearing at the list.

Fig. 91 is a typical illustration showing exemplarily a wiring among objects. Fig. 92 is a typical illustration showing a cable element list giving a definition of the wiring shown in Fig. 91.

According to the example shown in Fig. 91, an object A includes an object B, an object C, an object D and an object E. A bus 1 of the object B is connected to a bus 2 of the object C, a bus 2 of the object D and a bus 1 of the object E. Where the bus 1 of the object B serves as a bus (message terminal) for outputting an instruction, and each of the bus 2 of the object C, the bus 2 of the object D and the bus 1 of the object E serves as a bus (method terminal) for

receiving an instruction.

A wiring among these elements is defined, as shown in Fig. 92, by a cable element list connected to the object A (parent object). A number of cable elements are listed on the cable element list shown in Fig. 92. Of those cable elements, a cable element CABLEa defines a wiring between the bus 1 of the object B and the bus 2 of the object C, a cable element CABLEb defines a wiring between the bus 1 of the object B and the bus 2 of the object D, and a cable element CABLEc defines a wiring between the bus 1 of the object B and the bus 1 of the object E.

An instruction (message) outputted from the object B is transmitted to three objects C, D and E in each of which the associated method is executed. In this case, however, it happens that a problem as to an execution sequence among those methods is raised. For example, assuming that the object B serves as an object for inputting data from the exterior, the object C serves as an object for performing an arithmetic operation based on the data inputted, the object D serves as an object for making a graph based on a result of the operation, and the object E serves as an object for displaying the graph, there is a need to execute the respective methods in the order named of the object C, the object D and the object E in accordance with an instruction

indicative of that inputting of the data from the object B is completed.

Here, the wiring shown in Fig. 91 is unclear as to the execution sequence, and consequently, the execution sequence is displayed in the following manner and if necessary the execution sequence is altered.

Fig. 93 is a flowchart useful for understanding processings for a display of an execution sequence for methods and for an alteration of the execution sequence for the methods.

First, for example, while an image as shown in Fig. 91 is displayed, a desired wiring (here, the wiring shown in Fig. 91) is clicked through the mouse 104 to select the wiring of interest. In step 93\_1, the object coupling means 302 identifies the selected wiring. In step 93\_2, a cable list as to the selected wiring (cable) thus identified is made up and displayed.

Fig. 94 is a typical illustration showing a cable list element list.

When the cable list is made up, a cable element list of the parent object (object A) shown in Fig. 92 is retrieved, the cable elements CABLEa, CABLEb and CABLEc, which constitute the selected wiring, are identified, and pointers to cable elements are stored in cable list elements

constituting the cable list element list shown in Fig. 94 in the order listed in the cable element list. That is, in case of the present example, the pointers to three cable elements CABLEa, CABLEb and CABLEc, which constitute the selected wiring, shown in Fig. 92, are stored in the order named in the respective associated cable list elements arranged in the cable list element list shown in Fig. 94.

Fig. 95 is a view exemplarily showing a cable list displayed on a display screen 102a.

When the cable list element list as shown in Fig. 94 is made up, a state of the respective wiring for coupling two objects with each other is displayed with an arrangement according to the order listed in the cable list element list. Specifically, according to the example shown in Fig. 95, it is displayed on the first line that the bus 1 of the object B is connected to the bus 2 of the object C; it is displayed on the second line that the bus 1 of the object B is connected to the bus 2 of the object D; and it is displayed on the third line that the bus 1 of the object B is connected to the bus 1 of the object E. Where the line is referred to as a "list item". The left side of the cable list denotes a bus of the end for generating an message (instruction), and the right side of the cable list denotes a bus of the end for receiving and executing the message



(instruction) generated. In the practical operation, when the bus 1 of the object B issues the associated message (instruction), the respective methods are executed in accordance with the sequence shown in the cable list.

In step 93\_3 in Fig. 93, it is assumed that a line of list item indicated in the display list is dragged. Here it is assumed that the list item "object B : bus 1 object E : bus 1" appearing on the third line of the cable list shown in Fig. 95. In step 93\_4, the object coupling means 302 (cf. Fig. 64) identifies that a wiring for connecting the bus 1 of the object B to the bus 1 of the object E, that is, the wiring defined by the cable element CABLEc shown in Fig. 92 is dragged. In step 93\_5, the dragged list item is dropped. Where it is assumed that the dragged list item is dropped on the second list item "object B : bus 1 object D : bus 2" of the cable list shown in Fig. 95. In step 93\_6, the object coupling means 302 identifies that the wiring concerned in drop is a wiring for connecting the bus 1 of the object B to the bus 2 of the object D, that is, the wiring defined by the cable element CABLEb shown in Fig. 92.

Thus, when the dragged wiring and the wiring concerned in drop are identified, an arrangement sequence or the execution sequence is altered in such a manner that the dragged wiring is arranged before the wiring concerned in



arrangement sequence of the cable elements, in which the cable elements are arranged in the cable element list as shown in Fig. 96, is altered. Following this, an arrangement sequence of the cable list elements, in which the cable list elements are arranged in the cable list element list as shown in Fig. 98, is altered. According to this example, an arrangement sequence of the cable list elements is altered in such a manner that the cable list element storing therein the pointer to the cable element CABLEc is arranged before the cable list element storing therein the pointer to the cable element CABLEb, so that the cable list element list shown in Fig. 99 is made up.

Fig. 100 is a view showing a cable list in which an arrangement sequence has been altered.

As a result of alterations of the arrangement sequences of the cable elements and the cable list elements as mentioned above, the cable list for a display is also altered in a sequence of the list item, as shown in Fig. 100.

The above is an explanation of the embodiments of the interobject wiring editor unit 122 and its periphery. Next, there will be explained an explanation of the embodiments of the object builder unit 121 and its periphery.

The object ware programming system aims to perform an efficient programming through replacing programs by objects.

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For this reason, it is very important as to whether the existing software can be readily replaced by an object. Particularly, if it is possible to directly replace the existing software by an object, the number of the available objects is dramatically increased all at once, and as a result, a program development efficiency is extremely improved. Hitherto, there have been proposed several types of methods in which the existing software is replaced by an object. An OLE and a DDE in Windows are raised by way of example. However, according to those methods, it is needed to estimate beforehand at the existing software end that the existing software is replaced by an object. And thus, it is difficult to replace all of the existing softwares by objects. Further, even if the associated existing softwares are concerned, many of those softwares are involved in one which is very few in number of messages to be acceptable as compared with, for example, that of the graphical user interface. Accordingly, it is impossible to handle the existing softwares in a similar fashion to that of the graphical user interface.

With respect to a continuous operation for the existing softwares, hitherto, there is known a method in which a description is performed by the shell script. However, according to the earlier technology, it is difficult

to perform an operation for the software after the actuation in a similar fashion to that of the graphical user interface. Further, with respect to the description of the shell script, it must be performed by a user self and thus it will be difficult for a beginner user poor in experience of a programming to do so.

In view of the problems on building the objects as mentioned above, the embodiments, which will be described hereinafter, relate to a scheme of replacing the existing software by an object independently of types of the existing software, and a component which serves as an object in combination with the existing software. Here, there will be described, with the existing software having the graphical user interface as a main software, a scheme of replacing the existing software by an object, and a component which serves as an object in combination with the existing software.

A corresponding relation between the component described hereinafter and the present invention is as follows.

When the component, which will be described hereinafter, is stored in the storage unit 105 of the computer system 100 shown in Fig. 1, the storage unit 105 storing the component corresponds to one example of the component storage medium referred to in the present invention. In a case where the component is stored in the M0

110 shown in Fig. 1, the MO 110 storing the component corresponds to an alternative example of the component storage medium referred to in the present invention.

Fig. 101 is a typical illustration showing an embodiment of a component "including" an existing software having a graphical user interface.

In Fig. 101, an application A is an existing software in which while icons such as "button 1", "button 2", and "button 3" are displayed on the display screen 102a (cf. Fig. 1), anyone of those icons is clicked through an operation of the mouse so that a processing associated with the clicked icon is executed.

A window management unit manages a graphical user interface of all applications incorporated into the system, including the application A. For instance, if it is a Windows, the window management unit denotes a Windows system itself. A component A "including" the application A has a basic structure as an object, for connecting with other objects, and in addition data related to the application A. The component A has further as a method an application drive program and a window event generation program (e.g. a button 1 click event issue program for executing the equivalence to such a matter that a user clicks the button 1 through an operation of the mouse 104). When a message is

transmitted from another object to an application A drive method of the component A, the method is executed to drive the application A so that information (e.g. ID information and the like) related to the window is read and the component A maintains the window information.

Further, when a message is transmitted from another object (or one's own self) to a method which issues an event such as a button click or the like, the associated event is issued through the window management unit to the window of the application A in accordance with the event issue program described in the method which received the message.

In this case, it is possible to replace the existing application by an object by means of simply adding the component A, maintaining the existing application A as it is.

Fig. 102 is a typical illustration showing an alternative embodiment of a component "including" an existing software having a graphical user interface.

In the embodiment explained referring to Fig. 101, added to the last of the event generation program for the existing application A, the existing software and the like is a program for issuing a message to inform other object of that an execution of the method is finished. The message thus issued is connected to a method of other component or other object. Thus it is possible to execute a plurality of

methods on a chain basis. In Fig. 102, the existing software is omitted, and there is shown the state that the messages of the component A are connected to the methods of the components B and C.

Fig. 103 is a typical illustration showing a further alternative embodiment of a component "including" an existing software having a graphical user interface.

The component shown in Fig. 103 is an example of a component having such a function that events for the existing software are monitored and when a predetermined event is issued, the associated message is issued.

When a method for driving an application A of a component A being an existing software receives a message, the method is executed to drive the application A. The component A has a function to monitor all window events and investigates as to whether the issued event is involved in the application A. When it is identified that the issued event is involved in the application A, the component A issues a message for informing another object (or one's own self) of the fact that the event was issued for the application A. For example, when the icon "button 1" of three icons "button 1", "button 2" and "button 3" related to the application A, which are displayed on the display screen 102a, is clicked through an operation of the mouse 104 by a



user, the component A identifies that the icon "button 1" of the application A was clicked, and issues a message for informing that the button 1 was clicked.

In this manner, it is possible, upon receipt of an issue of the event of an existing software, to execute on a cooperative basis a method which does not appear on a specification of the existing software, without adding advanced functions to the existing software.

Fig. 104 is a typical illustration showing a structure of an event processing portion of the window management section shown in Fig. 103. Fig. 105 is a typical illustration showing a structure of an event monitor portion of the component A shown in Fig. 103.

The event processing portion of the window management section is a part in which upon receipt of the issue of an event, a processing associated with the event is carried out. The event processing portion has an event processing element list consisting of a plurality of event processing elements each storing therein pointers to various types of event processing functions. When a window event is generated, the event processing functions indicated by the pointers stored in each of the event processing elements are sequentially executed. The event processing element, which is arranged at the last of the event processing element list,

indicates a default event process function. The default event process function serves, for example, when a button is clicked, to perform such a processing that a button on the display screen is moved as if the button on the display screen is depressed.

At the last of a drive method of the application A of the component A show in Fig. 103, there is described a program for requesting the window management unit to transmit the window event to one's own self (component A). Specifically, the event processing element, which stores therein a pointer to an event monitor portion of the component A, is added to the event processing list possessed by the event processing portion of the window management unit. In this manner, it is possible thereafter to refer to the occurred event at the event monitor portion of the component A, whenever the window event occurs.

The event monitor portion of the component A stores an event table shown in Fig. 105 in which described are a window ID for defining events concerning the application A, an event ID, other data, and a message issued when the event issued, in their corresponding relation.

When any of the window events occurs and event data related to the occurred window event is inputted through the window management unit shown in Fig. 104 to the event monitor



corresponds to both the first handler and the second handler.

The component builder means 403 builds a component which serves as one object in combination with an existing software. Specifically, the component builder means 403 serves, when making of a method is instructed by an operation of the first handler 401 and a predetermined event of the existing software is issued by an operation of the second handler 402, to make on the component a method which fires with a message issued by another object and issues the event, and serves, when making of a message is instructed by an operation of the first handler 401 and an issue of a predetermined event of the existing software is instructed by an operation of the second handler 402, in response to an occurrence of the event, to make on the component a message for informing other objects of the fact that the event occurred.

The component builder means 403 corresponds to the object builder unit 121 of the object ware programming system 120 shown in Fig. 2.

Fig. 107 is a typical illustration useful for understanding an embodiment of a component builder apparatus according to the present invention. Fig. 108 is a flowchart useful for understanding processings of building a component using a component builder apparatus.

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An object builder portion 121 has a program 121a for building a component "including" or "involving" an existing software, which serves as one object together with the existing software. In step 108\_1, the existing software (here application A) "included" from the program is driven in accordance with an instruction from a user. In step 108\_2, window information of the application A is obtained and maintained.

Next, in step 108\_3, the user makes a selection as to whether a method or a message is added to the component "including" the driven application A, and further makes a selection as to types of events (for example, a distinction between the button click and the menu click). The selection between the method and the message mentioned above is carried out in accordance with such a way that either one of the icons of a method and a message on the display screen is clicked by the mouse. A name of the method or the message to be added is registered into the selected column through an operation of the keyboard.

In step 108\_4, an occurrence of events is monitored. When an event is generated by the button click or the like using a mouse (step 108\_5), it is determined as to whether the generated event relates to a window of the application A (step 108\_6). Further, in step 108\_7, it is determined as to

whether the generated event is the same type of event as the type (e.g. a distinction between the button click and the menu click) of the event selected in step 108\_3.

With respect to the mechanism (functions of the window management unit and the event monitor portion) for determining as to whether the generated event is a desired event, it is the same as that explained referring to Figs. 103 to 105. Thus, the redundant explanation will be omitted.

When the generated event is concerned with the window of the application A and in addition is of the same type as the selected event, the event is added to the component A in the form of the method or the message in accordance with a distinction between the method and the message selected in step 108\_3 together with the type of event. In other words, there is added a program such that when a message is received from another object at the component A "involving" the application A, a method of causing the event to generate is created, or when the event is generated, a message, which stands for that the event is generated, is informed to another object.

The above-mentioned operation is continued until a user gives an instruction for termination of monitoring an event (step 108\_9). Upon receipt of the event monitoring termination instruction given by the user, the application

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(application A) now on drive is terminated in drive.  
Further, with respect to an object comprising the application A and the component A "involving" the application A, object data for display and wiring as to such an object is created and stored in the object data file 132, and the object is compiled to create running object data and the running object data is stored in the running object file 133. In this manner, the component "involving" a desired existing software is built on an interactive basis.

Next, there will be explained embodiments of the fifth object-oriented programming supporting apparatus of the object-oriented programming supporting apparatuses according to the present invention.

Fig. 109 is a construction view of an object ware programming system in which structural elements corresponding to the embodiment of the fifth object-oriented programming supporting apparatus according to the present invention are added to the object ware programming system 120 shown in Fig. 2. In Fig. 109, the same parts are denoted by the same reference numbers as those of Fig. 2, and the redundant description will be omitted.

An object ware programming system 120' shown in Fig. 109 comprises, in addition to the structural elements of the object ware programming system 120 shown in Fig. 2, an event

log generating unit 141, a component coupling unit 142, an event log file 151 and a component file 152.

According to the embodiments of the component builder apparatus explained referring to Figs. 107 and 108, the built component is stored in the object data file 132 and the running object file 133. On the contrary, according to the present embodiment shown in Fig. 109, while it is the same as the former embodiment with respect to the running object file, data for display and wiring of the built component is stored in the component file 152 instead of the object data file 132. It is to be noted that for the purpose of better understanding, the component file 152 is formed independently of the object data file 132, but it is acceptable that the component file 152 and the object data file 132 are constructed in the form of united body.

First, in accordance with the scheme explained referring to Figs. 107 and 108, upon receipt of a message, an event of an existing software is issued, and a component, which outputs it in the form of a message that the event is issued, is built on each of a plurality of existing softwares and stored in the component file 152.

Next, a user drives simultaneously or sequentially those existing softwares in many number to generate a various types of events. Then, the event log generating unit 141



generates an event log indicative of as to what event is generated in what order. The event log thus generated is stored in the event log file 151.

When a generation of the event log is terminated, the component coupling unit 142 sequentially reads the events stored in the event log file 151 and wires the components stored in the component file 152 so that the events read out are sequentially generated.

A wiring result is stored in the interobject wiring data file 134. Further, if necessary, an additional wiring is conducted by the interobject wiring editor unit 122, and then the wiring is converted into wiring data for an interpreter use and stored in the wiring data file 135 for an interpreter use.

Fig. 110 is a flowchart useful for understanding an operation of a component coupling unit. Fig. 111 is a flowchart useful for understanding an operation of a component coupling unit.

As shown in, Fig. 111, <sup>the</sup> ~~th~~ event log file stores therein an event log in which a number of event data are arranged, which is generated in the event log generating unit 141 (cf. Fig. 109). The component file (cf. Fig. 109) stores therein a number of components in which the event is associated with the method in accordance with a manner



exists. Thus the wiring between a method and the previous message, as shown in Fig. 111, is not conducted, and a message, which is issued when the method issuing the event is executed, is saved in the form of the "previous message".

In this manner, it is possible to implement an automatic wiring among components. This wiring makes it possible in execution by the interpreter unit 123 to automatically sequentially issue events in accordance with the sequence of generation of the event log by a user, and thus an automatic operation for the existing software is possible.

When the event log is once produced, the automatic wiring is conducted sequentially in accordance with the sequence of the events arranged on the produced event log. It is also acceptable, however, that the event log once produced is displayed in the form of a table, and a user selects a necessary event from the table displayed so that an automatic wiring is conducted in accordance with a sequence selected by the user. According to this way, it is possible, when errors occur during a generation of an event log, to correct the errors without doing over again in generation of the event log.

In this manner, it is possible to implement, for example, an autopilot function of the WWW browser, by means

of implementing an automatic operation of the application.

Next, there will be explained an alternative embodiment of a scheme in which an existing software is "involved" and replaced by an object, and an alternative embodiment of a component which serves as an object in combination with an existing software.

Fig. 112 is a conceptual view showing a state in which an existing software is "included" in a component. Fig. 113 is a view showing a table for definition items to give various definitions shown in Fig. 112. In Fig. 113, the object is referred to as "LSI".

Here, the existing software is an existing program consisting of a function or a set of functions, not solely executed but executed when called from other application program or the like.

In the existing programming, there exist data  $x_1, x_2, x_3, \dots, x_i, \dots$  to be received from other programming, functions function 1, function 2  $\dots$ , function  $j, \dots$  for performing a processing based on the received data, and data  $y_1, y_2, \dots, y_i, \dots$  to be transmitted to other program, which are representative of a result of processing.

When such a program is "involved", as shown in Fig. 112, it is assumed that an object is defined with a separation into two parts. The separating way is given with

a certain degree of option, and may be determined by a user.

Here, various types of definitions are given as shown in Fig. 112. First, as (A) a header, there are defined a project name for specifying the whole of works or processings and an environment for executing the processings.

(A) a header is followed by (B) a definition to be made up, (C) a definition of an existing program (defining as to which existing program is to be replaced by an object), and (D) a definition of an object. It is noted that (D) a definition of an object is given with a plurality of definitions when the existing program is partitioned into a plurality of objects.

In (D) a definition of an object, there exist a definition of a data bus (a data input terminal) for use in data input for identifying a pointer which receives data from other object, a definition of a method (a method terminal) for identifying a pointer of an entrance of the processing to be executed, and a definition of a data bus (a data output terminal) for use in data output for identifying a pointer for data to be transmitted to other object. It is to be noted that according to the present embodiment, since the existing program adapted for executing a processing when called from other program is assumed, it is not considered that this existing program requests (an issue of message) of

another object a processing.

Fig. 113 is a view showing a table for definition items to give various definitions shown in Fig. 112.

The keyword groups appearing on the table are of a kind of program language useful for giving the above-mentioned various definitions. A detailed explanation of the individual keywords will be omitted, since it is not essential to the present invention.

Fig. 114 is a view exemplarily showing images displayed on a display screen 102a when definitions are given.

The left side of the screen shows structures of definitions, each of which serves as an icon. When any of the icons is clicked, there is displayed as shown at the right side of the screen a frame of a table for giving a definition of the item associated with the clicked icon. Filling the frames one by one completes a definition table.

An adoption of such a type of scheme that the frames of the table is filled makes it possible to readily give a definition on an interactive basis.

When the definition table is completed, an existing program and a component comprising the definition table related to the existing program are stored in the object data file 132 with an extraction of data for display and wiring by the object builder unit 121 shown in Fig. 2, and also are

stored in the running object file 133 through a conversion into a running format by a compiler.

In this manner, it is possible to take in an existing software to the object ware programming system in the form of the object, regardless of a format of the existing software, maintaining the existing software as it is.

As described above, according to the present invention, it is possible to specially enhance reuse of the software, and also to implement the software higher in the running speed.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by those embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.